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USE OF MANAGEMENT INFORMATION SYSTEMS ON UNITED STATES GOVERNMENT CONTRACTS: A FIRST EVALUATION OF THREE CASES

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Information Systems which generate useable management data are of critical importance to both the government and industry who are involved in Research and Development effort. Failure to generate such data can have disasterous consequences in terms of products which do not meet objectives and uncontrollable expenditures which bite deeply into profits. The objective of this paper is to determine the effectiveness of information systems used on Government contracts by three local Aerospace companies.

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CHAPTER 1

INTRODUCTION

The United States Government procures an enormous variety of goods and services from American industry each year and it is therefore particularly vulnerable to the perils of the old market-place adage CAVEAT EMPTOR. For the Department of Defense (DOD) who, on large advanced state of art contracts spends billions of dollars, the vulnerability becomes intense due to the fact that original contract objectives cannot be guaranteed and costs at contract completion, sometimes years into the future, cannot be reasonably controlled. The problem of cost control and objectives achievement intensifies significantly when Government funding requirements change with changing National priorities or when industry capabilities are exceeded thus requiring reprogramming entire contracts.

Congressional records show case after case of major weapon systems development and acquisition over-runs and the press has reported many of the more serious cases. Rarely is mention made of systems which are developed and produced within the time and dollar constraints originally set. The problem was highlighted in 1973 by Dr. J. S. Foster when he noted in Congressional testimony that " within the past twenty years the cost of defense weapons systems acquisition has been rising at more than five times the rate of inflation."[1]

[1]Dr. John S. Foster, Jr., Director, Defense Research and Engineering, Defense Management Journal, (July 1973), page 4.

It thus becomes absolutely necessary that industry generate and the Government obtain useable management information throughout the period of the contract for visibility, status reporting and decision making. It is to this end that the Government and industry invest substantial sums of money. Ten to twenty percent of the entire cost of Government Research and Development contracts is devoted to management and management systems.[2] In spite of this investment, the record shows many cases where managers at all levels are completely surprised by overwhelming adverse management information- and at times too late to affect corrective action. A recent illustration occurred on January 20, 1976 when, although not a DOD contractor, the Wall Street Journal reported that the Government Employees Insurance Company (GEICO) had suffered disasterous losses during its last quarter and "the magnitude of GEICO's losses staggered me".[3]

The visibility required by todays Government Research and Development contracts covers the spectrum of functional disciplines within a company and to a depth of detail which at times must be overwhelming. Specific contract requirements demand periodic technical, schedule progress and cost progress reports be submitted for customer Government

[2] Edward Offenhartz Elms and P. M. Grumman, Aerospace Corp. Defense Management Journal, (April 1974), page 25.

[3] Thomas A. Harnett, New York State Insurance Superintendent, GEICO, Wall Street Journal, (January 20, 1976), page 4.

analysis . Other terms and conditions may include provisions for periodic visits by technical and management experts to personally assess status and progress. Within the DOD, two organizations, the Defense Contract Administration Service (DCAS) and the Defense Contract Audit Agency (DCAA), with a total National strength of approximately twenty thousand federal employees,[4] exist solely for the purpose of assessing U. S. Government DOD contract performance. In addition to the above dedicated surveillance agencies, various purchasing offices have attached additional analysts to perform comtract status duties.

Government surveillance efforts, regardless of the interested agency, depend almost entirely upon contractor furnished information - technical reports, cost account ledgers, schedules, plans, efficiencies, etc. The industry managers themselves depend on much of this same information in order to manage their corporations, divisions, companies, programs or projects. The primary source of all this information, whether it be for internal or external use is the company's own information system.

On large Government contracts, 98% of cost status and 75% of schedule status[5] visibility is derived from the company's computer-based information system. Technical

[4] The author is currently on assignment from the United States Air Force to DCAS, Bridgeport.

[5] Jacques S. Ganslor, Deputy Assistant to the Secretary of Defense (Mat Acq) OASD 1&2, Defense Management Journal, (October 1975), page 1.

visibility is based mostly on face to face personal contact - engineer to engineer. However, even here the company MIS is steadily making headway toward providing current, accurate technical status in the areas of configuration management and simulation techniques.[6]

This paper is a first examination of three U. S. Government Research and Development contracts of intermediate value - each with a different company. This examination is made with the following objectives:

1. Determine the degree of conformity by the companies with current literature concepts on Research and Development (R and D) program management schemes. This determination will be made by reviewing selected concepts of R and D management and information requirements; noting those which seem logical or from the author's experience are tried and proven; examining each company's approach to its own R and D project; comparing the company's methods against those recommended by the literature and then analyzing the variance between the two.

2. Determine the depth of visibility provided by each company to both the government and company management. An examination will be made of selected project data which is generated by each company for use by management and customer. Particular attention will be made of timeliness of data delivery to management and customers, currency of delivered

[6] Rita McCarthy, Burroughs Corporation, Defense Management Journal, (October 1975), page 23.

data, detail of the effort to be performed as to Work Breakdown and responsibility, detail of the data in terms of cost, schedule and performance, relation of the data to the contract (project) in question, sophistication of the information in terms of Automatic Data Processing Equipment (ADPE) use and amount of reports generated for use on the project.

3. Determine the effectiveness of each company's information system to provide management with useable data. Management information will be reviewed at the company with selected examples collected for inclusion in this report. The review will determine data which is considered necessary and that which is not (for management purposes): it will determine if cost, schedule and performance data are reported, at which level, whether variances from plan are calculated, whether variance analyses are produced and whether estimates to contract completion are provided. A status of each company's R and D program will be determined as of 31 December 1975 and an analysis will be made to determine whether data from that time period gave management correct status, variances (if any), and identification of the cause (s) for variance.

4. Determine whether there is any measurable relationship between the degree of conformance with current literature concepts of R and D management systems and depth of visibility on the one hand (1 & 2 above) and the effective-

ness of each company's system as it is applied to R and D projects A, B, and C on the other (3 above).

This evaluation is a snapshot at one point of time (relatively early in all three contracts) and the conclusions must necessarily be considered tentative. Follow-up studies later in the programs and after contract completions should be made in order to properly verify (or contradict) the preliminary conclusions of this study.

CHAPTER 2

INFORMATION SYSTEM BASELINE

This chapter presents the results of a literature search to highlight desirable characteristics of an Information System oriented toward Government funded Research and Development programs. It also contains the considered opinions of company MIS directors and Program Managers who were asked to identify desirable Information System attributes.

It is necessary now to insure understanding of the words "Information System" as used in this paper. It is, as previously suggested, the combination of ingredients within a company which produce data for project (contract) status, visibility and decision making. It includes project control personnel whether program office or functionally organized; it includes the MIS department (personnel, hardware and data) and it includes both company and customer analysis. It is primarily concerned with cost and schedule information and the internal and external thereof.

Prior to contract award, in most cases, the company must decide on the allocation of responsibilities for the contract: either a project office or the more customary functional organization. The following table compares the organizations from each viewpoint.[7]

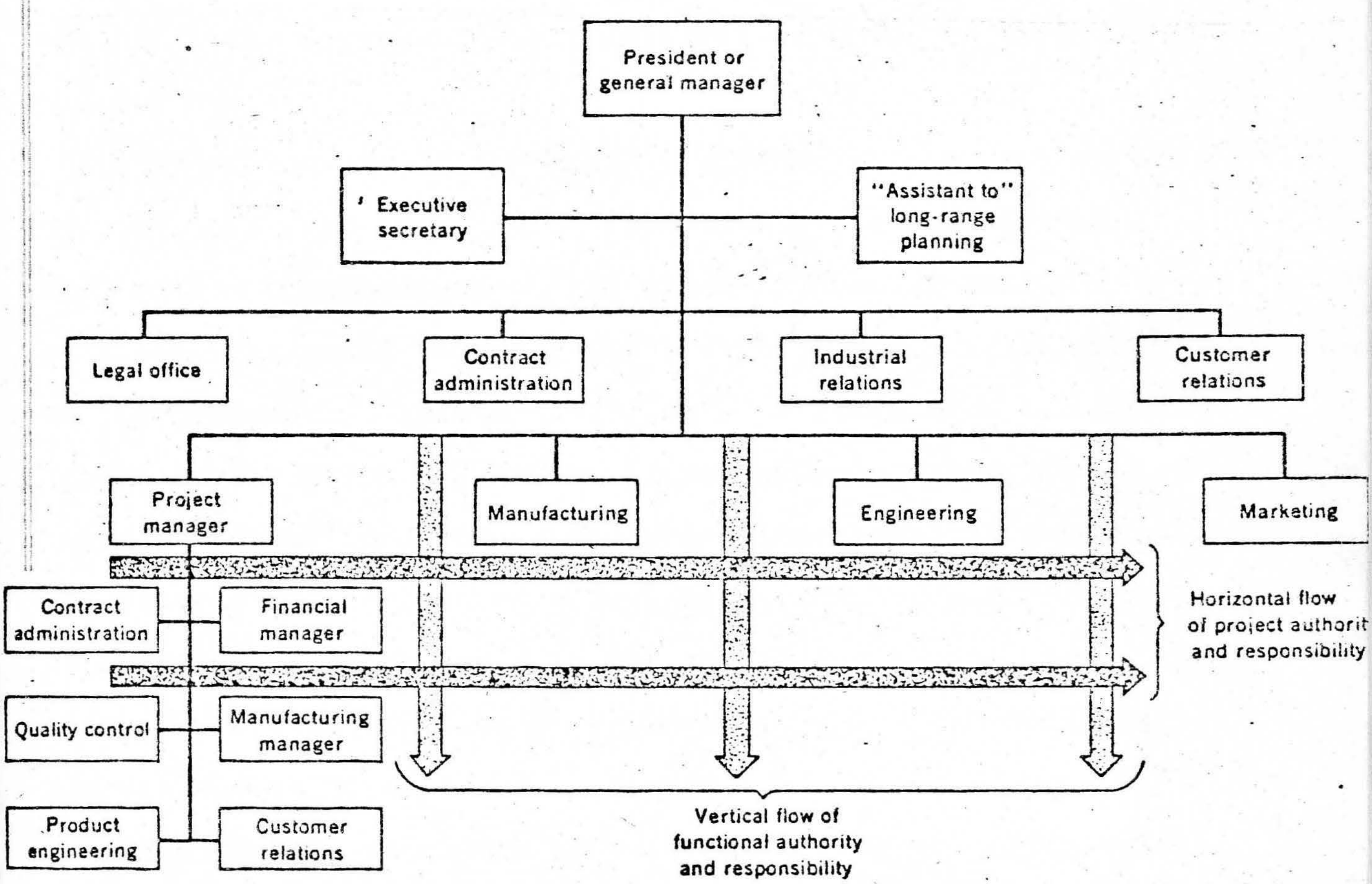
[7] Cleland and Hill, Systems Analysis and Project Management, (1968), page 153.

Table 7-1. Comparison of the functional and the project viewpoints

PHENOMENA	PROJECT VIEWPOINT	FUNCTIONAL VIEWPOINT
Line-staff organizational dichotomy	Vestiges of the hierarchical model remain, but line functions are placed in a support position. A web of authority and responsibility relationships exists.	Line functions have direct responsibility for accomplishing the objectives; line commands, and staff advises.
Scalar principle	Elements of the vertical chain exist, but prime emphasis is placed on horizontal and diagonal work flow. Important business is conducted as the legitimacy of the task requires.	The chain of authority relationships is from superior to subordinate throughout the organization. Central, crucial, and important business is conducted up and down the vertical hierarchy.
Superior-subordinate relationship	Peer-to-peer, manager-to-technical-expert, associate-to-associate, etc., relationships are used to conduct much of the salient business.	This is the most important relationship; if kept healthy, success will follow. All important business is conducted through a pyramiding structure of superiors and subordinates.
Organizational objectives	Management of a project becomes a joint venture of many relatively independent organizations. Thus, the objective becomes multilateral.	Organizational objectives are sought by the parent unit (an assembly of suborganizations) working within its environment. The objective is unilateral.
Unity of direction	The project manager manages across functional and organizational lines to accomplish a common interorganizational objective.	The general manager acts as the one head for a group of activities having the same plan.
Parity of authority and responsibility	Considerable opportunity exists for the project manager's responsibility to exceed his authority. Support people are often responsible to other managers (functional) for pay, performance reports, promotions, etc.	Consistent with functional management; the integrity of the superior-subordinate relationship is maintained through functional authority and advisory staff services.
Time duration	The project (and hence the organization) is finite in duration.	Tends to perpetuate itself to provide continuing facilitative support.

It can be stated from experience that the U. S. Government desires the program or project office organization concept on all large and intermediate value Research and Development contracts in order to achieve singular responsibility. From the above chart, the phenomena of "unity of direction" would be the key factor. The "dedicated" team approach of the program office is contractually required in many large R and D contracts.

Notice in the following organization chart how a program office operates horizontally through the vertical structure of the functional set-up.[8]



A Harvard Business Review article about management methods for Aerospace summarized the function of a program office very succinctly: "...a close knit organization, established for the deliberate fostering of conflict resolution, with rapid and thorough communication, high intensive visibility and great attention to detail."[9]

[8] Cleland and Hill, op. cit., page 168

[9] J. G. Milliken and E. J. Morrison, Harvard Business Review, "Management Methods for Aerospace", (March-April 1973), page 8.

It is concluded that when there is a choice, the selection of a program office for management of intermediate and large Research and Development contracts, rather than a functional organization, serves the best interest of both the company and the customer.

A major concern of the R and D manager is the problem of communication and information flow within the organization. Many of the organization's ills are diagnosed as communication problems, yet until recently there were no systematic studies of the process of "information flow". The Research and Development organization may be considered an open sub-system that imports information, money, equipment and technical personnel. The exports may consist of a designed product for manufacture or information which would be the import for another organization.[10] Information flow interfaces for a R and D organization are schematically depicted in Figure 1.[11]

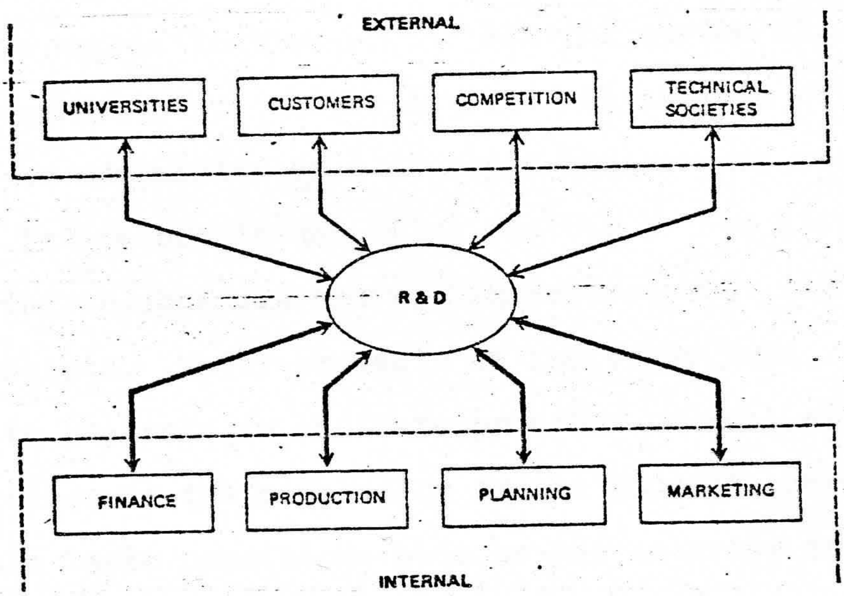
Remembering, as quoted above, that a program office exists for the purpose of "conflict resolution", and as shown in Fig. 1, obtains information from both internal and external interfaces, the conflict referred to by Murdick and Ross can be practically and logically divided into three parts: cost conflicts, schedule conflicts, and technical conflicts. Therefore the job of the program office is to control these conflicts

[10] R. G. Murdick and J. E. Ross, Information Systems for Modern Management, (1971), page 75.
[11] Murdick and Ross, op. cit., page 76.

within some established constraints: the negotiated contract cost, schedule and performance requirements. The key, of course, to understanding and identifying these conflicts is in the detailed planning, scheduling, and defining the work at the lowest organizational level.

FIGURE 1

INFORMATION FLOW INTERFACE



Managerial controls, whatever the type, provide the project manager with the tools for determining whether or not the organization is proceeding toward its objective as planned. Controls also advise the program manager of the extent of deviations in terms of costs, schedule or performance. It is for the program office experts (financial analysts, engineers, contract administrators, or the program manager) to conduct sufficient in-depth analyses to generate appropriate, corrective action.

Control has to do with making events conform to plan. Control uses the information from the past to develop the necessary actions for the future. Since control is forward-looking, deviations from plans should be identified and reported to the manager as soon as possible. Control therefore, must be established in terms of deviation from plan early enough so that corrective action can can instituted before progress is impaired.

The sophistication of the control system depends on the complexity of the project and the ability of the participants to administer it. A simple project may require only a few indicators to determine whether or not it is progressing on schedule and within desired cost and performance constraints. Major projects on the other hand, require extensive controls to indicate progress as well as problems. Regardless of the complexity of the project, however, certain basic conditions must be met in order to have a workable system.[12]

- It must be understood by those who use it and obtain data from it.
- It must relate to the project organization, since organization and control are interdependent; neither can function properly without the other.
- It must anticipate and report deviations on a timely

[12] D. I. Cleland and W. R. King, Systems Analysis and Project Management, (McGraw Hill, 1968), page 247.

basis so that corrective action can be initiated before more serious deviations actually occur.

- It must be sufficiently flexible to remain compatible with the changing organizational environment.
- It must be economical so as to be worth the additional maintenance expense.
- It should indicate the nature of the corrective action required to bring the project back into consonance with the plan.
- It should reduce to a language (words, pictures, graphs or other models) which permits a visual display that is easy to read and comprehensive in its communication.
- It should be developed through the active participation of all major executives involved in the project.

Whatever information is chosen for control, it must enable the manager to forecast for the future. An analogy may be drawn to airplane stall warning devices. One type of device informs the pilot that his aircraft is going to stall, but does so only at the precise moment of actual stall, thus only verifying what the pilot now knows. The other type of device anticipates the stall sufficiently in advance that the pilot can take corrective action and actually prevent the stall.

The best information system may not keep a manager out of trouble, but it should keep him advised of current (near real time) conditions. The following steps have been offered in designing a project information system.[13]

- Identify the long range objectives of the project.
- Analyze the existing information system in terms of its suitability for your program.
- Identify and provide for interfacing of the project information system with the over-all information system for the company.
- Establish a time plan for the development and implementation system.
- Accomplish the plan.

An information system is a complex of formal and informal networks for communicating among project participants. It can vary widely in degree of formality, ranging from a highly structured method such as Program Evaluation Review Technique (PERT) to personal talks among project members.

One of the more distressing trends in project management is the tendency to rely heavily on complicated, sophisticated management information systems. There is very real danger that the manager can become so preoccupied with the system that he fails to exercise enough personal management of his program.

Schedule, cost and technical progress are the basic elements of project control. Information systems which continu-

[13] Cleland and King, _op. cit._, page 251

ously appraise schedule and cost parameters are necessary.

Schedule control consists of integrating all the project schedules, including the over-all schedule and the detailed schedules for each segment of work. These schedules may be integrated by means of, say, PERT or a variation of the Gantt chart.

Cost control has to do with the organization, administration and control of the cost procedure necessary for the project. It encompasses the accumulating of all actual costs. The primary functions of cost control are to document historical costs and to compare these costs periodically with the planned expeditures.

Cost and schedule status are reported quite simply in terms of dollars and time periods, (weeks, months, etc.). Technical status can be, and is, reported in an infinite variety of ways.

As mentioned in Chapter I and reaffirmed during the literature search, "......the most promising source of information regarding technical progress is the technical personnel. Be making value judgments and opinions, technical status can be credibly determined."[14]

During interviews with MIS directors, Mssrs. L. S., Company A, L. D., Company B, and R. T., Company C, it was determined that automatic data processing equipment build up

[14] Cleland and King, op. cit., page 258.

at each company was at best evolutionary and several times revolutionary. In each company, initial requirements for ADPE stemmed from engineering or the scientific groups, who for purely scientific purposes and subsequent competitive edge, successfully convinced management of the desirability to lease or purchase such equipment. On the business side of each house it appears that the needs of the accounting departments made the most convincing argument for ADPE. It was through this evolutionary succession, plus the ultimate employment of skilled professionals, systems analysts, programmers and operators, and the extremely high costs of continuous new leases and/or purchases for each new small group whowho desired some ADPE capability, that current highly integrated and flexible management information and scientific data processing centers have evolved.

The information systems literature is sketchy on information regarding specific computer hardware size, numbers and capabilities. The literature does discuss sufficiency - that is, the rent or purchase of ADPE should result from a Long-Range cost effectiveness trade study comparing benefits to liabilities. Current sophistication in the use of ADPE systems, again based on discussions with the above mentioned MIS directors, stems mainly from the size of company profits and the dynamic persuasive ability of the individual director.

To be successful, the project information system must contain five basic ingredients: relevance, timeliness, economy, accuracy, and flexibility. A system for a large project should be highly structured and formalized so that as changes occur in the project scope or time schedules, program office personnel can quickly become aware of the effect of those changes on his own efforts.

The Defense Department, always sensitive to cost overruns, schedule delays and poor technical performance on Research and Development contracts, has embraced an information system which is complex and far reaching. As directed in DOD Instruction 7000.2, formal Cost/Schedule Control Systems Criteria (C/SCSC) is required on many complex programs. C/SCSC provides the basic customer to contractor interface for program visibility. A fundamental responsibility of DOD managers concerned with the acquisition of systems is to insure that the visibility of contractor's progress is sufficient to reliably indicate the results being obtained.[15] In carrying out this responsibility in selected contracts within applicable Defense programs, appropriate procurement program offices and other DOD agencies receive and review cost, schedule, and technical performance data. Such data, to be reliable, consistent, and to provide adequate visibility of contract performance, must be derived from the same internal system as that used by the contractor

15 Air Force Systems Command pamphlet 173-3 C/SCSC Implementation Guide, (July 1969), pages 1-2.

to manage his contract effort.

It is recognized that no single common set of management control systems will meet every DOD and contractor management data need for performance measurement. Variations in organizations, products, and working relationships prohibit the use of a universal system (s). Therefore, the DOD adopted an approach which simply defines some 35 criteria that contractor's performance measurement systems must meet. The 35 are grouped under five major catagories:

- Organization
- Planning and Budgeting
- Accounting
- Analysis
- Revisions and Access to Data [16]

The responsibility for providing the specific concepts and operating procedures for complying with these criteria is vested in the contractor, but the specific system the contractor proposes is subject to DOD approval processes.

By applying criteria rather than requiring a specific system, contractors are provided with latitude and flexibility in meeting their unique management needs. This approach allows contractors to use existing systems, or other systems of their choice, provided that these systems meet the C/SCSC.

[16] Air Force Systems Command pamphlet 173-3, op. cit., pages 3-4.

The key features of C/SCSC are:

1. A contract Work Breakdown Structure (WBS) must be generated.
2. Responsibility for program progress and expeditures should be specifically assigned to individuals.
3. Variances from plan in terms of schedule and cost must be calculated monthly for each work package of the WBS.
4. Specific analysis must be conducted for all variances and corrective action taken.
5. "Estimate at Contract Completion" must be updated continuously.

SUMMARY

As a review and a summary of the conclusion of the literature search phase a comparison to the original objectives is briefly made:

1. Many sources were examined to determine the requirements of modern information systems on the control of Government Research and Development programs. This chapter has presented a number of desirable characteristics recommended by the literature: a program office rather than a functional organization; freedom of information flow both internally and externally; generation of data which compares actual status with planned and shows deviations in a timely manner; data which forecasts in terms of cost, schedule and performance,

efficient use of ADPE and MIS group personnel; advanced control techniques such as PERT, MOST, and C/SCSC.[17]

The attempt here is to highlight current thinking in terms of the management of Government R and D projects. The following chapters will explore the degree of conformity to these requirements exhibited by each of three companies on their respective Government Research and Development contracts.

2. The depth of visibility into a program is expressed in terms of the program's organization (either functional or project), the internal and, to a lesser extent, the external flow of information regarding the program and its environment, the degree of definition of the particular program, internally and externally, the sophistication of the information system and the adroitness of the personnel who are responsible for the program. The recommended depth of visibility is usually a consequence of the desires of both company and customer and should be no more than that necessary for effective control.

3. The effectiveness of management information is measured on balance by the program's adherence to plan at any given time. More specifically, the information system must provide cost, schedule, and technical status; it must provide

[17] Further details on the C/SCSC are beyond the intended scope of this paper.

sufficient analyses to determine the cause of cost, schedule and performance variances and it should anticipate total cost, schedule, and technical impacts at the completion of the project.

CHAPTER III

COMPANY A

Company A is a multinational company whose products and services cover a wide range of technical disciplines. The company develops and produces scientific instruments, laboratory analytical instruments, precise optics, electro-optics, lasers and electronic components. These products are used for a wide variety of research, control, test, and space and National security programs. The company's annual sales for 1975 totaled approximately $300 million [18] with its principal domestic manufacturing facilities in Connecticut and CAlifornia. The particular program selected for analysis in this paper is denoted Project A. Project A is a Research and Development contract with the U. S. Air Force for use in the Airborn Laboratory, a specially configued Boeing 707. The contract was started in June, 1975 and will continue for some 24 months; its total value is $3-5 million. Since follow-on production effort is a distinct possibility and highly dependent on the success of the development effort, the company professes to be extremely sensitive to costs, schedule and technical progress milestones.

The key to success of Project A was recognized by Company A to be its ability to control the development effort. During the pre-contract award phase the company decided to establish

[18] Company A Annual Report, (1975), page 26.

a program office thus giving the customer his own dedicated team of experts completely devoted and committed to the success of the program. In addition to the Program Manager, the program office is staffed by a full-time financial analyst, contract administrator, and several engineers. For schedule generation and analysis a part-time program scheduler is available.

To provide a consistent visible framework of activities to effectively plan, manage and assign technical responsibilities and to provide continuous control over program progress the development of a Work Breakdown Structure (WBS) is required. [19]

The WBS is structured at the first level of indenture in terms of the key program elements. Subsequent levels of indenture depict basic job elements, e.g., quality assurance, major hardware assembly. The major elements are further subdivided to the point at which tasks and sub-tasks are assignable and manageable in terms of performing organizational units. Each block in the WBS is assigned a unique identification code number. The task numbers are used for planning and control of schedules and costs.

In conjunction with the WBS, a master schedule (page 25) was developed. Every task is related to a network activity and to an organizational unit; thus, there is a cross-vali-

[19] <u>Cost Proposal Report</u>, 12470, page 122.

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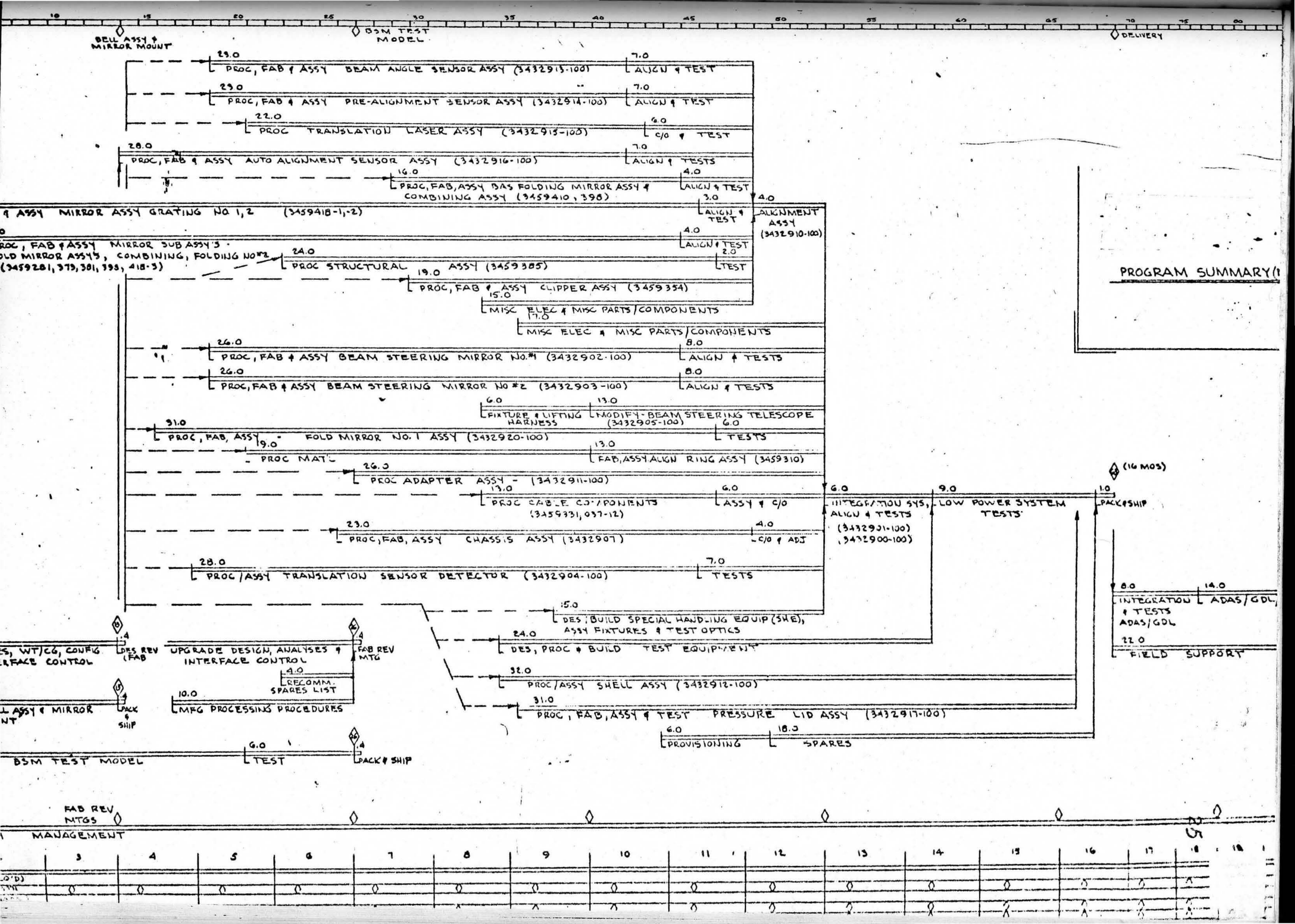
- TATION
  - 00
- DESIGN — 20,000
  - 20100 - Design Modifications
  - 20200 - Engineering Drawings
  - 20300 - Ground Handling Equipment
  - 20400 - Test Equipment and Fixtures
- ANALYSIS — 30,000
  - 30100 - Mechanical/Structural
  - 30200 - Servo
  - 30300 - Optical
  - 30400 - Safety
  - 30500 - Open Port
- FABRICATION — 40,000
  - ASSEMBLY 3432900-100 — 41,000
    - ALIGN ASSY INSTALLATION 3432901-100 — 41,100
      - ALIGNMENT ASSY 3432910-100 — 41,110
        - BEAM ANGLE SENSOR ASSY — 41,111
        - PRE-ALIGN SENSOR ASSY 3432914-100 — 41,112
        - TRANSLATION LASER ASSY 3432915-100 — 41,113
        - AUTO-ALIGN ANGLE SENSOR ASSY 3432916-100 — 41,114
        - REFLECTION GRATING #1 3432922-100 — 41,115
        - REFLECTION GRATING #2 3432923-100 — 41,116
      - BEAM STEERING MECH TELESCOPE 3432905-100 — 41,120
      - ADAPTER ASSY 3432911-100 — 41,130
      - PRESSURE SHELL ASSY 3432912-100 — 41,140
      - PRESSURE LID ASSY 3432917-100 — 41,150
    - BEAM STEERING MIRROR ASSY #1 3432902-100 — 41,200
      - 41210 BS Assy #1
    - BEAM STEERING MIRROR ASSY #2 3432903-100 — 41,300
      - 41310 BS Assy #2
    - TRANSLATION DETECTOR ASSY 3432904-100 — 41,400
    - ELECTRONIC EQUIPMENT — 41,500
    - FOLD MIRROR ASSY 3432920-100 — 41,600
    - WEIGHT AND CG ANALYSIS — 47,000
  - GROUND HANDLING EQUIPMENT — 42,000
    - 42100 - Align Assy Support Stand
    - 42200 - Align Assy Removal Fixture
    - 42300 - Beam Steering Lifting Fixture
    - 42400 - Pressure Shell Removal Fixture
    - 42500 - ADAS Mechanical Fixtures
  - TEST EQUIPMENT AND FIXTURES — 43,000
    - 43100 - APT Simulator
    - 43200 - Vibration Fixture
    - 43300 - Electrical Systems (STE)
    - 43400 - Aux. Test Equip (ATE)
    - 43500 - Aux. Optics
  - CABLES — 44,000
    - 44100 - ADAS/Aircraft Cables
    - 44200 - ADAS/ARTF
    - 44300 - ADAS/Lab Test
  - QUALITY CONTROL — 45,000
    - 45100 - Program Surveillance
    - 45200 - Hardware Interface
    - 45300 - Test Surveillance
    - 45400 - Equipment Modifications
    - 45500 - Component Selection
  - INTERFACE CONTROL — 46,000
  - WEIGHT AND CG ANALYSIS — 47,000
- INTEGRATION AND TEST — 50,000
  - 50100 - Subsystems
  - 50200 - Low Power Test
  - 50300 - ADAS/GDL
  - 50400 - ADAS/GDL/APT
- BREADBOARD SUPPORT — 60,000
  - 60100 - Ltwt. and Te
  - 60200 - Valve
  - 60300 - BDAS
  - 60400 - BSM T

A001 Data Accession List/Internal Data
A002 R&D Status Report
A003 Contract Work Breakdown Structure (CWBS)
A004 Cost/Schedule Status Report (C/SSR)
A005 Contract Funds Status Report (CFSR)
A006 System Safety Engineering Report
A007 Electromagnetic Compatibility Plan
A008 Recommended Spare/Repair Parts List
A009 Equipment Test Plan
A010 Test Reports - General
A011 Revised/Supplementary Data for Engineering Drawings
A012 Data, Engineering, Reports, and Lists for Research and Development Work Performed at Government Expense
A013 Drawings and Associated Lists, Preparation of (Non-Government Design Activity) Form 3
A014 Technical Publications for Development Programs O&M Manual - Flight Hardware
A015 Program Schedule
A016 Still Photo Coverage
A017 Subsystems Modification Design Data and Reports Technical Notebook
A018 Task and Skill Analysis Report, Technical Support Plan
A019 Agenda - Design Reviews, Configuration Audits and Demonstrations
A020 Minutes of Formal Reviews, Inspections and Audits
A021 Interface Control Document
A022 Technical Reports, Open Port Analysis Report



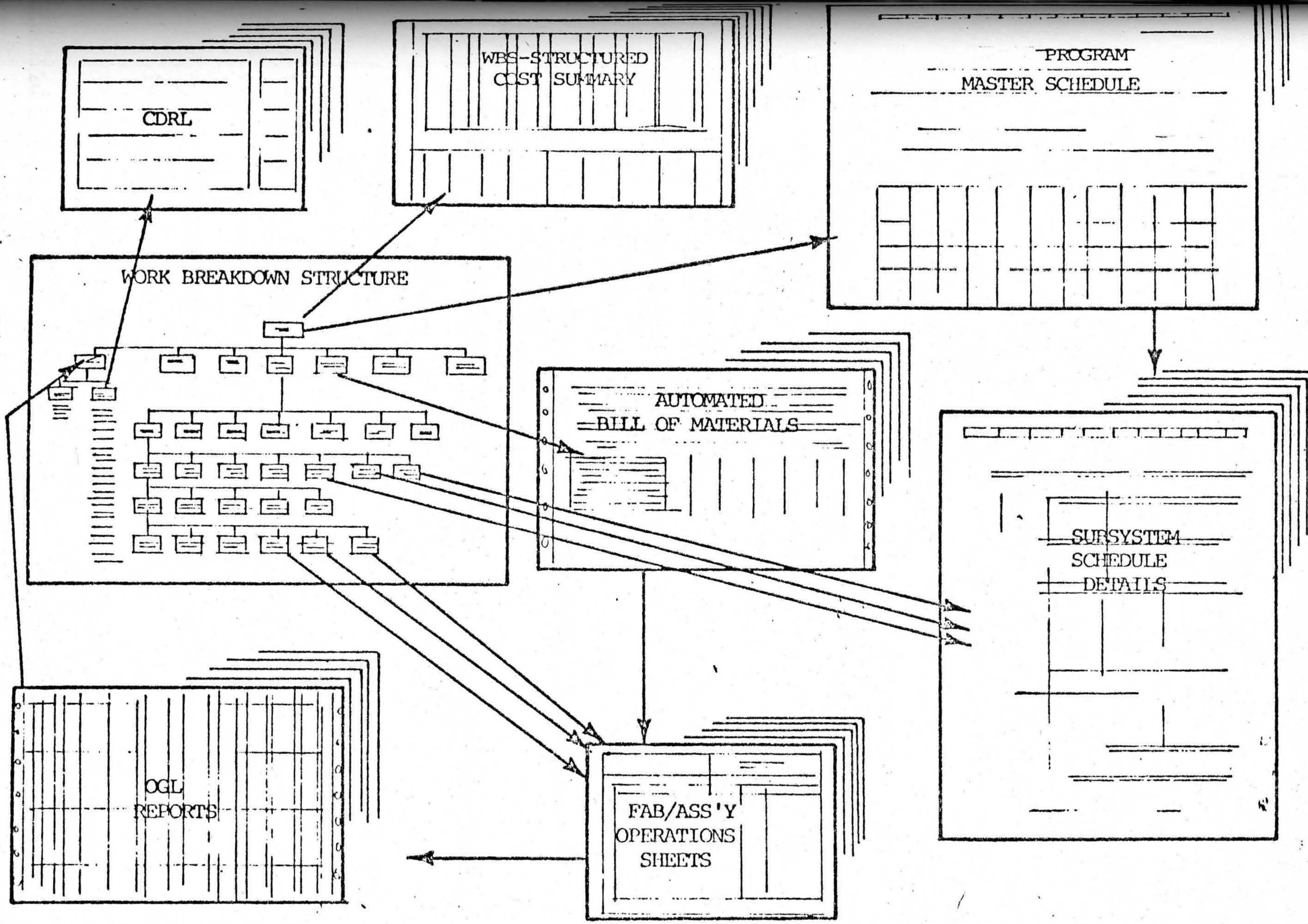
BELL ASSY & MIRROR MOUNT
BSM TEST MODEL
DELIVERY
23.0 PROC, FAB & ASSY BEAM ANGLE SENSOR ASSY (3432913-100)
7.0 ALIGN & TEST
23.0 PROC, FAB & ASSY PRE-ALIGNMENT SENSOR ASSY (3432914-100)
7.0 ALIGN & TEST
22.0 PROC TRANSLATION LASER ASSY (3432915-100)
6.0 C/O & TEST
28.0 PROC, FAB & ASSY AUTO ALIGNMENT SENSOR ASSY (3432916-100)
7.0 ALIGN & TESTS
16.0 PROC, FAB, ASSY BAS FOLDING MIRROR ASSY & COMBINING ASSY (3459410, 398)
4.0 ALIGN & TEST
& ASSY MIRROR ASSY GRATING NO. 1, 2 (3459418-1,-2)
3.0 ALIGN & TEST
4.0 ALIGNMENT ASSY (3432910-100)
PROC, FAB & ASSY MIRROR SUB ASSY'S - FOLD MIRROR ASSY'S, COMBINING, FOLDING NO. 2 (3459281, 373, 301, 393, 418-3)
4.0 ALIGN & TEST
24.0 PROC STRUCTURAL ASSY (3459385)
2.0 TEST
19.0 PROC, FAB & ASSY CLIPPER ASSY (3459354)
15.0 MISC ELEC & MISC PARTS/COMPONENTS
17.0 MISC ELEC & MISC PARTS/COMPONENTS
26.0 PROC, FAB & ASSY BEAM STEERING MIRROR NO. 1 (3432902-100)
8.0 ALIGN & TESTS
26.0 PROC, FAB & ASSY BEAM STEERING MIRROR NO. 2 (3432903-100)
8.0 ALIGN & TESTS
6.0 FIXTURE & LIFTING HARNESS
13.0 MODIFY-BEAM STEERING TELESCOPE (3432905-100)
6.0 TESTS
31.0 PROC, FAB, ASSY FOLD MIRROR NO. 1 ASSY (3432920-100)
9.0 PROC MAT'L
13.0 FAB, ASSY ALIGN RING ASSY (3459310)
26.0 PROC ADAPTER ASSY - (3432911-100)
13.0 PROC CABLE COMPONENTS (3459331, 037-12)
6.0 ASSY & C/O
23.0 PROC, FAB, ASSY CHASSIS ASSY (3432907)
4.0 C/O & ADJ
28.0 PROC/ASSY TRANSLATION SENSOR DETECTOR (3432904-100)
7.0 TESTS
6.0 INTEGRATION SYS, ALIGN & TESTS (3432901-100), 3432900-100)
9.0 LOW POWER SYSTEM TESTS
1.0 PACK & SHIP
(16 MOS)
15.0 DES, BUILD SPECIAL HANDLING EQUIP (SHE), ASSY FIXTURES & TEST OPTICS
24.0 DES, PROC & BUILD TEST EQUIPMENT
32.0 PROC/ASSY SHELL ASSY (3432912-100)
31.0 PROC, FAB, ASSY & TEST PRESSURE LID ASSY (3432917-100)
6.0 PROVISIONING
18.0 SPARES
8.0 INTEGRATION & TESTS ADAS/GDL
14.0 ADAS/GDL
22.0 FIELD SUPPORT
PROGRAM SUMMARY
S, WT/CG, CONFIG INTERFACE CONTROL
DES REV (FAB
UPGRADE DESIGN, ANALYSES & INTERFACE CONTROL
FAB REV MTG
4.0 RECOMM. SPARES LIST
10.0 MFG PROCESSING PROCEDURES
L ASSY & MIRROR NT
PACK & SHIP
BSM TEST MODEL
6.0 TEST
PACK & SHIP
FAB REV MTGS
MANAGEMENT
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

dation of task, schedule and responsible organization using the WBS number as a key. Once the network is finalized, it is converted to a MOST (Management Operation System Technique) format that keys activities to calendar times. The MOST network is the primary in-house schedule monitoring medium used by Company A on such projects. As such it is a familiar method to the engineering personnel.

The relationship of the master schedule to the overall management network is shown on page 27.

An integral part of the management system for the project will be the use of the MOST chart for planning, scheduling, and controlling activities. MOST provides the user with the data necessary to determine when an activity is scheduled to begin and to end; the activities which require prior completion, and what other activities hinge on completion of the subject activity. In addition to displaying deadlines, the MOST network shows task status. A MOST plan incorporates all the elements of the Work Breakdown Structure and their interrelationships. Each bar of a MOST plan consists of a defined, controllable task or group of tasks that spans an estimated time period at a budgeted cost. The planned start and/or complete date is interrelated with all other activities that comprise the total program.

the estimated duration of each activity or task on the Project A program was based on the combined experience of



Program Monitoring Network

engineering and manufacturing personnel who have conducted similar tasks on prior programs. Specific cost and schedule reports used by the Program Manager and the Production Control Manager are listed on page 29.[20]

Costs are budgeted and controlled in terms of the WBS tasks and work packages and the performing organizational units. Electronic data processing reports from the Corporation's accounting system provide the Program Manager and Project Administration daily, weekly and monthly with the following:

(a) Program costs, by task and sub-task, by performing organization, and by element of cost.

(b) Direct labor hours and dollars, by task and sub-task, by performing organization and by labor code.

(c) Commitment Report, by task and sub-task, and by outstanding commitments.

Over-all financial control of each division is through the office of the Division Controller, who has responsibility to both the Division General Manager and the Corporate Controller through the Group Controller. In this manner, the local cost control function conducted on the program level is subject to a dual channel of upward checks and balances: through the divisional route via normal program reporting

[20] Cost Proposal Report, 12470, page 124.

REPORT NO.	COST AND SCHEDULE REPORTS	FREQ.
OGL 04	Standard vs Actual Performance by Work Center; All Lot Closures Previous Week	Weekly
OGL 08	Released Load per Work Center per Week; All Lot and Sequence Closures Removed; Detail by Part Number	Weekly
OGL 13	Released Load per Work Center per Work Order (WO); Balance of Hours per WO per Work Center	Weekly
OGL 18	Released Load per Work Center per Week; All Lot and Sequency Closures Removed; Summary by Work Center - No P/Ns	Weekly
OGL 32	Jobs Charged Yesterday by Work Center; Hours Charged Yesterday and Cumulative to Date	Daily
	PART NUMBER SORTED REPORTS	
OGL 05	Standard vs Actual Performance by P/N; All Lot Closures Previous Week	Weekly
OGL 14	Operation Sheet Outline by P/N; All Lots Released - Previous Day	Daily

REPORT NO.	COST AND SCHEDULE REPORTS (Continued)	FREQ.
	PROJECT SORTED REPORTS	
OGL 38	Selected WO Detail Part Number Status; Work in Process File Only; Sorted by WO and Part Number	Daily
OGL 26	Selected WO Detail Part Number Status; Work in Process File Only; Sorted by WO and Part Number	Weekly
OGL 30	Selected WO Detail Part Number Status; Historical File Only; Sorted by WO and Part Number	Monthly
OGL 10 & 24	Summary Listing of all Work in Process Sorted by Sales Order and Part Number, One Line Entry per Job	Monthly
OGL 11 & 23	Detail Outline of Jobs Closed This Month Sorted by Sales Order and Part Number Analysis of all Jobs Moving to Historical File	Monthly
OGL 47	Selected WO Weekly Rework Charges Sorted by WO, Task, P/N; Type of Rework One Week Rework only - No History	Weekly
OGL 42	Selected WO Cumulative Rework Charges Sorted by WO, Task, and P/N; Combined History and Work in Process Rework	Monthly
OGL 19	Summary Listing of Entire Historical File Sorted by Sales Order and Part Number, One Line Entry per Job	Demand
OGL 20	Selected WO Weekly Std/Act. Variances Sorted by Work Center; Combined History and Work in Process Rework	Demand

channels, and through the corporate financial route via the several levels of controllers.

The elements of the program management system have now been described. Highlights of the system are:

. Variances to plan are the in-put to control decisions

. Daily cost and schedule data are available

. Automated Bill of Materials is used

. Shop Load Plan

. Program Schedule Plan

. Program Cost Plan

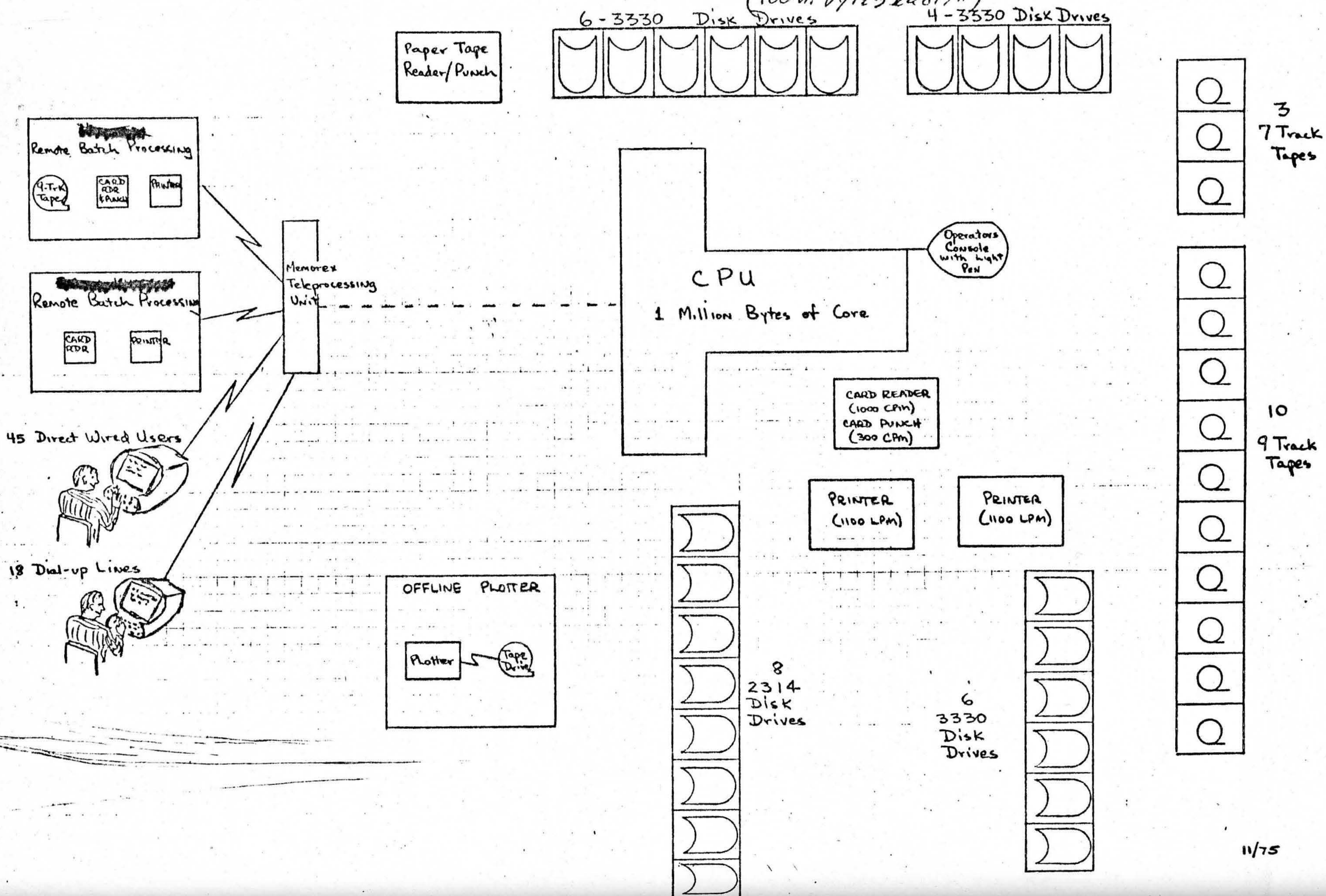
The reports resulting from this control system are shown on page 29; the Work Breakdown Structure provides the overall monitoring function after task responsibility specifically assigned to individuals at the fourth or fifth level.

In full support of Project A and other program offices is the Management Information System Department. Primary support to the program office is accomplished by providing operating personnel, supervisors, technical staff, middle and top management with accurate and timely business, technical and administrative support information to help them meet the challenges and solve the problems they encounter in carrying out their respective assignment.

The current hardware set-up in the facility is organized as shown on the following schematic.[21] The department provides

[21] Provided by MIS Director, Company A.

370/158 FACILITY



11/75

MIS computer support for planning, procurement, fabrication and inspection functions.

All computer operations are organized under the Executive Vice-President of Finance and Administration. The Scientific Computer Facility and Corporate MIS consolidated in 1970, forming the Corporate Computing Facility.

Examples of several reports used by the Program Office to determine periodic detailed cost and schedule status are shown on the following pages. From this type of internal data, the Project Control Report, weekly estimate at completion, the Cost Control System, the trend analysis (computed manually) and others (pages 33 -36) the external Cost/Schedule Status Report and Cost Funds Status Report are generated (pages 37 -39). It should be noted that the Cost/Schedule Status Report is, for external purposes, probably the most valuable data generated. It provides in a single report: cost, schedule, variances of each to plan and the estimated program completion funding requirements. It does not, however, provide analyses for determination of variance cause. It should be noted that all schedule status reporting, analyses and alerts are completed manually by the Management Program Planning Specialist and are therefore vulnerable to his physical availability.

SUMMARY: Company A conforms quite remarkably to current literature ideas and concepts: a program office for its

		CURRENT MONTH HOURS	AMOUNT	CONTRACT TO DATE HOURS	AMOUNT
SECT. 02620 PROD ASSURANCE	LABOR *	11.0	100.48	142.0	1,191.37
	OVERHEAD*		121.68		1,987.09
	TOTAL *	11.0	222.16	142.0	3,178.46
PAR POOL 08 FIELD SERVICE	LABOR **	11.0	100.48	142.0	1,191.37
	OVERHEAD**		121.68		1,987.09
	TOTAL **	11.0	222.16	142.0	3,178.46
OVERHEAD POOL 22 E-O MANUFACTURING	LABOR ***	184.5	1,781.02	2,548.8	22,044.18
	OVERHEAD***		2,117.23		36,767.49
	TOTAL ***	184.5	3,898.25	2,548.8	58,811.67
G&A POOL 1 ELECTRO-OPTICAL DIV.	LABOR ****	189.5	1,809.36	2,566.3	22,149.90
	OVERHEAD****		2,147.69		36,894.68
	TOTAL ****	189.5	3,957.05	2,566.3	59,044.58
SECT. 08523 OTD ENGINEERING	LABOR *			8.0	80.37
	OVERHEAD*		.32-		87.28
	TOTAL *		.32-	8.0	167.65
OVERHEAD POOL 31 OTD ENGINEERING	LABOR ***			8.0	80.37
	OVERHEAD***		.32-		87.28
	TOTAL ***		.32-	8.0	167.65
G&A POOL 7 INTER-DIVISIONAL	LABOR ****			8.0	80.37
	OVERHEAD****		.32-		87.28
	TOTAL ****		.32-	8.0	167.65
TOTAL LABOR	LABOR *****	189.5	1,809.36	2,574.3	22,230.27
	OVERHEAD*****		2,147.37		36,981.96
	TOTAL *****	189.5	3,956.73	2,574.3	59,212.23
VOUCHER					4,457.86
TRAVEL					66.18
CORP. COMP. FACIL.			11.60-		138.00
MAJOR SUB-CONTRACTS					
TOTAL NON-LABOR			11.60-		4,662.04
TASK 13XXXX SUMMARY TOTAL		189.5	3,945.13	2,574.3	63,874.27

*** TASK 21110 DETAIL

SECT. 02619 OPTICAL QA	LABOR *			1.0	5.38
	OVERHEAD*		.23-		8.97
	TOTAL *		.23-	1.0	14.35
PAR POOL 06 PRODUCT ASSURANCE	LABOR **			1.0	5.38
	OVERHEAD**		.23-		8.97
	TOTAL **		.23-	1.0	14.35
OVERHEAD POOL 22 E-O MANUFACTURING	LABOR ***			1.0	5.38
	OVERHEAD***		.23-		8.97
	TOTAL ***		.23-	1.0	14.35
G&A POOL 1 ELECTRO-OPTICAL DIV.	LABOR ****			1.0	5.38
	OVERHEAD****		.23-		8.97
	TOTAL ****		.23-	1.0	14.35
TOTAL LABOR	LABOR *****			1.0	5.38
	OVERHEAD*****		.23-		8.97
	TOTAL *****		.23-	1.0	14.35
VOUCHER					299.52
TOTAL NON-LABOR					299.52

SPO 33141
TASK 12000

		CURRENT WEEK					CUM TO DATE			
		HOURS	LAB&OVH	N-LAB	TOTAL		HOURS	LAB&OVH	NON-LAB	TOTAL
EOD ENGINEERING	ACT:	37	535	0	535	ACT:	563	7844	34	7878
	EST:	30	562	0	562	EST:	660	11799	0	11799
	VAR:	7-	27	0	27	VAR:	97	3955	34-	3921
MANUFACTURING	ACT:	0	0	0	0	ACT:	0	0	67	67
	EST:	0	0	0	0	EST:	0	0	0	0
	VAR:	0	0	0	0	VAR:	0	0	67-	67-
** TASK TOTALS **	ACT:	37	535	0	535	ACT:	563	7844	101	7945
	EST:	30	562	0	562	EST:	660	11799	0	11799
	VAR:	7-	27	0	27	VAR:	97	3955	101-	3854
**** TOTAL AUTHORIZED TASK BUDGET ****							1350	24739	0	24739

TIMATE AT COMPLETION
RU WEEK ENDING AUGUST 22,1975

	C H G	DESCRIPTION	PROG MGR	CON- TRAC TYPE	SELL PRICE	PROFIT FEE	G M RESERVE	BUDGET	AUTHRZD TOT CST FUNDING	ACTUALS TO DATE	EAC	DATE OF EAC	VAR FROM BUD CURR	PRIOR	CONT DATE	EST DATE
158	01			CPFF	2,933.5	254.5	.0	2,679.0	319.6	60.0	319.6	08-20-75	2359.4	2359.4	02-25-76	09-10-75

TREND ANALYSIS

'L'

	5-30	6-13	7-11	REMARKS
DRUM ASSY (HSG-23)(MACH DRUM-9)	+8	-17	-23	
CHOPPER ASSY (CONNECTORS-20)(WHEEL-7)	-7	-23	-20	SPECIAL 'H' CONN.
SOFTWARE PROGRAMMING	-9	0	-19	WAITING FOR DISC
DATA CABLE (ASSY ONLY)	0	—	-17	WAITING FOR VENDOR QUOTES
DATA LOG RACK	+5	+2	-8	WAITING FOR RACK & MISC
SENSOR RACK	-3	-13	-6	WAITING TO PLACE P.O.'S
VACUUM CHAMBER	—	—	-2	QUOTES
CALIB LASER ASSY	+7	-8	0	BEAM EXPANDER ASSY
BENCH	+5	0	+1	
HYPERBOLA MIRROR	+19	+2	+1	
INTERF OPTICS (0017, 0018) (LENS)	+17	+7	+10	
BEAM DIRECTING MIRRORS (0041)	+21	-6	+14	
REAL TIME DRAWER.	+3	+4	C	

U 7-1475

[illegible] ☒ PRODUCTION ☐	CONTRACT TYPE/NO.		REPORT PERIOD		OMB NUMBER
	CPIF-CPFF	F29601-76-C-0016	12/26/75	Sr. Contract Accountant January 14, 1976	22R0327

Contract Data

(1) ORIGINAL CONTRACT TARGET COST	(2) NEGOTIATED CONTRACT CHANGES	(3) CURRENT TARGET COST (1) + (2)	(4) ESTIMATED COST OF AUTHORIZED, UNPRICED WORK	(5) CONTRACT BUDGET BASELINE (3) + (4)
$3,178,700	$114,000	$3,292,700	-	$3,292,700

Performance Data

WORK BREAKDOWN STRUCTURE	CUMULATIVE TO DATE					AT COMPLETION		
	BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		BUDGETED	LATEST REVISED ESTIMATE	VARIANCE
	Work Scheduled	Work Performed		Schedule	Cost			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
10000 Prog. Mgt.	83.6	83.0	81.5	(.6)	1.5	346.0		
20000 Design	298.4	263.6	255.4	(34.8)	8.2	441.5		
30000 Analysis	51.0	51.2	52.2	.2	(1.0)	77.7		
40000 Fabrication	270.3	310.1	191.4	39.8	118.7	1031.1		
50000 Integration & Test	.3	0	.4	(.3)	(.4)	393.6		
60000 Bread Board Support	33.1	38.8	29.2	5.7	9.6	99.3		
SUB-TOTAL	736.7	746.7	610.1	10.0	136.6	2389.2		
GEN AND ADMIN	213.6	216.3	176.9	2.7	39.4	692.8		
UNDISTRIBUTED BUDGET						-		
MANAGEMENT RESERVE						210.7		
TOTAL	950.3	963.0	787.0	12.7	176.0	3292.7		

CONTRACT NUMBER	3. CONTRACT FUNDING FOR FY	5. PREVIOUS REPORT DATE	7. CONTRACTOR (NAME, ADDRESS & ZIP CODE)	9. INITIAL CONTRACT PRICE:
29601-76-C-0016	FY 76 (INC)	28 November 1975		TARGET 2647.5 CEILING -
CONTRACT TYPE	4. APPROPRIATION	6. CURRENT REPORT DATE	8. PROGRAM	10. ADJUSTED CONTRACT PRICE
PIF-CPFF	*	26 December 1975		TARGET 2740.8 CEILING -

FUNDING INFORMATION

LINE ITEM/WBS ELEMENT a.	APPROPRIATION IDENTIFICATION b.	FUNDING AUTHORIZED TO DATE c.	ACCRUED EXPENDITURES PLUS UNLIQUIDATED COMMITMENTS TOTAL d.	CONTRACT WORK AUTHORIZED Definitized e.	Est. Over/Under Target Cost f.	Not Definitized g.	Subtotal h.	FORECAST Not Yet Authorized i.	All Other Work j.	Subtotal k.	TOTAL REQUIREMENTS l.	FUNDS CARRY-OVER m.	NET FUNDS REQUIRED n.
TOTAL	*	2114.0	861.8	2740.8	--	-	2740.8	--	--	--	2740.8	--	2740.8

CONTRACT WORK AUTHORIZED (WITH FEE/PROFIT) - ACTUAL OR PROJECTED

	ACTUAL TO DATE	JAN.	FEB.	MAR.	APR.	MAY	JUNE				At Completion
UNLIQUIDATED COMMITMENTS	210.5	238.1	139.1	54.2	32.8	11.0	11.0				696.7
ACCRUED EXPENDITURES	651.3	252.7	233.1	261.8	260.7	214.7	169.8				2044.1
TOTAL (12a + 12b)	861.8	490.8	372.2	316.0	293.5	225.7	180.8				2740.8
FORECAST OF BILLINGS TO THE GOVERNMENT	650.2	323.2	362.6	437.7	420.6	353.6	180.8				-

REMARKS:

AA 5763600 296 4704 660001 000000 00000 63000F 662300 F62300 AFSWC

IF-CPFF	*	26 December 1975		TARGET [illegible] CEILING -

FUNDING INFORMATION

LINE ITEM/WBS ELEMENT	APPROPRIATION IDENTIFICATION	FUNDING AUTHORIZED TO DATE	ACCRUED EXPENDITURES PLUS UNLIQUIDATED COMMITMENTS TOTAL	CONTRACT WORK AUTHORIZED				FORECAST			TOTAL REQUIREMENTS	FUNDS CARRY-OVER	NET FUNDS REQUIRED
				Definitized	Est. Over/Under Target Cost	Not Definitized	Subtotal	Not Yet Authorized	All Other Work	Subtotal			
a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.	l.	m.	n.
TOTAL.	*	--	--	854.7	--	--	854.7	--	--	--	854.7	--	854.7

	CONTRACT WORK AUTHORIZED (WITH FEE/PROFIT) - ACTUAL OR PROJECTED										
	ACTUAL TO DATE	JULY-	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.		At Completion
. UNLIQUIDATED COMMITMENTS	--										
. ACCRUED EXPENDITURES	--	166.5	121.5	111.7	88.1	89.7	88.9	100.1	88.2		854.7
. TOTAL (12a + 12b)	--	166.5	121.5	111.7	88.1	89.7	88.9	100.1	88.2		854.7
3. FORECAST OF BILLINGS TO THE GOVERNMENT	--										-

REMARKS:

AA 5763600 296 4704 660001 000000 00000 63000F 662300 F62300 AFSWC

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Classification

Page __ of __ Pages

R and D project, program data which shows cost/schedule variance and estimates to completion, apparent efficient use of ADPE and personnel, the use of one of the more advanced scheduling techniques; MOST, the detailed breakdown of work (WBS) and the timely use of data. Limited authority within the program office for costs, the lack of detailed variance analyses and the suceptibility of the program schedule to manual variance analyses are apparent divergences from the literature which may indicate a weakness in Company A's information system for Project A.

Visibility for internal and external use appears to be quite adequate: daily, weekly, and monthly data deliveries showing current program status, full use of ADPE and personnel, a detailed Work Breakdown Structure, frequent personal visits by the scheduling expert, and a fully integrated coherent relationship of all data to the contract program. As shown on the Cost/Schedule Status Report, cost and scheduledata are displayed, variances (cost and schedule) are shown along with a budgeted cost at completion. The subsequent Contract Funds Status Reports show sequentially the company fiscal year '76 and '77 estimated requirements as of 31 Dec. 1975. Since, at that time, the program was ahead of schedule and in an under-run cost condition, variance analyses may not be crucial. However, from the governement (or customer) viewpoint one is thus deprived of visibility and details which should highlight the variance cause.

CHAPTER IV

COMPANY B

Corporation B is a company whose annual sales exceed three billion dollars and whose various divisions produce products for the generation of power, for the traditional aerospace market, and whose Research and Development efforts approach fifteen percent of sales.[22]

The Company B Division is primarily responsible for the development and production of a family of related telecommunications products. Located in Connecticut, the Division currently carries approximately one hundred million dollars of U. S. Government contracts in addition to a substantial commercial market. Among its many product lines, Project B ranks third in total dollar value. For this paper, two engineering change proposals (ECP) were chosen for examination. Each ECP develops and qualifies sub-systems for increased use, accuracy, and reliability. The value of the changes proposed is 5.4 million dollars. The contract was let in September, 1975 with a stipulation that the Research and Development effort be completed by August, 1976. There is a production follow-on task planned.

Project B provides all necessary altitude, navigating, weapons delivery and autopilot instrument data to the pilot and co-pilot of a current USAF tactical fighter plane. The displays, both development and production, have been under

[22] Company B Annual Report, (1974), page 21.

contract periodically since 1972. Major modifications are now being implemented by the Government. Within the company a program office was established in 1971 to serve as the primary contractor focal point for the previous project efforts. The program office has maintained its viability through the years and now with seven dedicated members, manages the subject engineering changes. Like Company A, the office is staffed with a program manager, a planner/schedulor, a contracts manager, a financial controller, and several engineers. In addition to the above office a staff of three proposal assistants are assigned for the express purpose of providing for future business, these people are not required to manage current operations.

Upon receipt of the contract, Company B rather than create a Work Breakdown Structure, (discussed in detail in Chapter III), used a Program Directive[23] which accomplishes the over-all purposes of a WBS, but in much less detail. The Program Directive assigns specific responsibilities for the various parts of the contract Statement of Work, names responsible individuals, and establishes a program milestone schedule. This document authorizes work to begin and dollars to be spent within the project program office. A master schedule is prepared by the program office as shown on page 47. It is simple; with milestone completion and data submittal

[23] Project B <u>Program Directive</u> (excerpts), (October, 1975), Subj. VSD ECP, page 52.

PROGRAM DIRECTIVE

P.D. NO. 1.371	
S.O. REF. 7900	
PAGE 1 OF 1	
DATE 7 October 1975	

ECT: Program Plan for VSD ECP 52 (Attached)

RENCE:

This Program Directive is your direction to proceed with the design, manufacture and incorporation of the improvements described in ECP 52 as delineated in the attached plan. This plan is based upon SMALC's direction to proceed and is subject to modification when the contract is executed. Any deviation to this plan must be approved by the Program Office prior to implementation.

If there are any questions, please contact , extension 2282.

Program Manager

BD/cd
Attachment

cc:

(10/69)

PART II

FUNCTIONAL TASKS

Program Office

Has the prime responsibility for coordination of all effort required to accomplish the design and manufacture of the kits and incorporation of the kits into the hardware delineated in the schedule.

Will maintain this plan.

Contracts

Has the prime responsibility for contract interpretation and issuing all requirements via Sales Order. In addition, Contracts will provide the primary interface with SMALC. All data required under this contract will be sent out via the Contracts Department and where approval by the customer is required, Contracts will obtain and inform the functional departments when such approval is received.

Negotiate all effort over and above the requirements of this contract (i.e., shipping containers) and authorize such effort via Sales Order prior to the commencement of such effort.

Financial

Will maintain current work authorizations covering all required effort and report on financial status as required by the Program Manager.

Engineering

Has the prime responsibility for defining the modifications required to accomplish the fixes described in ECP 52.

Will generate kit definitions for the modifications.

Will be responsible for the kit proofing of the first unit.

Will support Operations as required to accomplish the modifications of ECP 52 including the areas of:

a. Test and Debug

b. Configuration Management

c. Discrepant Material Review

d. Producibility

e. Other areas as required.

Will generate the data items identified in Part I, Requirements, paragraph 6 a-e and 6 g-i.

Will generate the TCTO for submission to the customer.

Will provide the PMO with monthly progress reports for the engineering effort.

Will conduct the Design Verification Test.

Operations

Will manufacture the kits identified in Part I, Requirements.

Will perform an incoming ATP on each unit received for modification.

Will incorporate modification kits in the hardware delineated in Part I, Requirements.

Will generate purchase requisitions for the material required to manufacture the modification kits.

Will perform an ATP or COP on all modified hardware as applicable.

Will fabricate any required shipping containers as authorized via Sales Order.

Will determine the serviceability of the two (2) VSDs supplied as GFE for Design Verification Testing.

Will maintain the two (2) VSDs used for Design Verification Testing.

Product Assurance

Will *conduct quality surveillance of all in-process effort to incorporate the modifications in the hardware specified in* Part I, Requirements.

Will witness the formal ATP.

Will maintain configuration and serialization logs for all modified hardware.

Product Support

Will prepare all Logistics Data as specified in paragraphs 6.g and j of Part I, Requirements.

Will issue SROs to cover all items input for modification.

Will generate all requests for shipment.

Will generate AFTO 349 Forms for each modified item.

Purchasing

Upon receipt of purchase requisitions from Production Control, will establish vendors, place orders and insure delivery in time to support the kit delivery schedule.

Will prepare the necessary shipping documents and insure that distribution is accomplished in accordance with Contract Provisions.

Will accomplish the actual shipment of modified hardware.

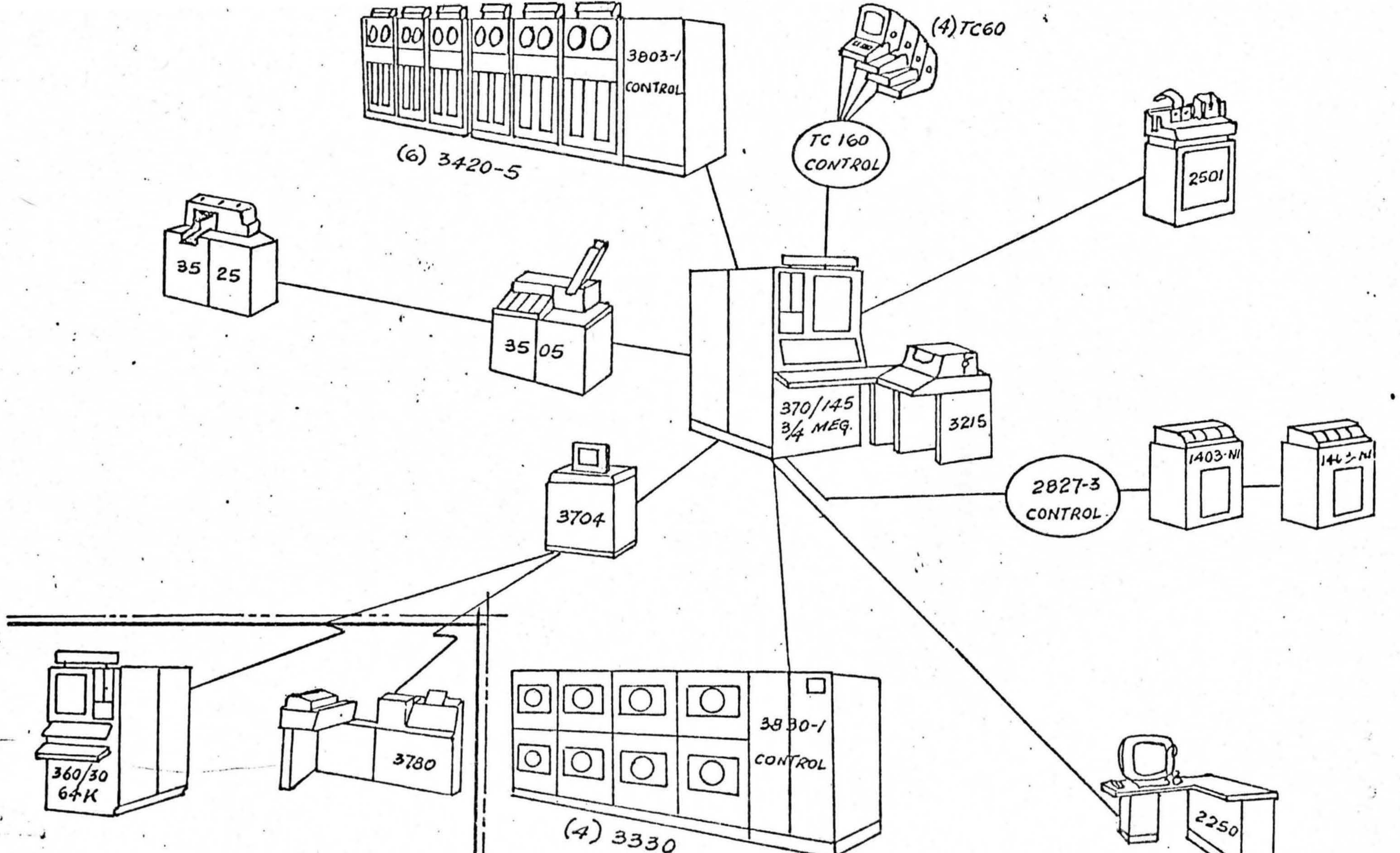
	1975									1976																						
	10/5	10/12	10/19	10/26	11/2	11/9	11/23	12/7	12/21	1/4	1/18	2/1	2/15	2/29	3/14	3/28	4/11	4/25	5/9	5/23	6/6	6/20	7/4	7/18	8/1	8/15	8/29	9/12	9/26	10/10	10/24	11/7
CONTRACT AWARD	△																															
REC'V GFE TEST UNITS		△																														
PRELIM PARTS REL				△																												
PARTS FOR TEST AVAIL									△																							
MOD OF GFE COMP										△																						
ENG TEST COMP													△																			
REL FINAL ECN														△																		
PROCUREMENT COMP																					△											
PARTS AVAIL																							△									
FAB/ASSY/TEST																											△					
DATA: ATS														△																		
ATP														△																		
DES VERIF TEST PROC				△																												
DES VERIF TEST REPT																△																
DRAWINGS/MICROFILM														△																		
LOGISTICS DATA																△																
TEST REQ DOC																△																
TEST FLOW DIAGRAM																△																
LRU ATS									△																							
OVERHAUL MANUAL																△																
INT MAINT MANUAL																△																
KIT PROOFING TCTO																												△				
TCTO NEGATIVES																																△

dates only shown. It then becomes necessary for the responsible organization to detail internal schedules for management and visibility purposes.[24] Over-all program budgeting is controlled by the program office financial controller. It is again through a properly authenticated Work Authorization form that budgeted direct-labor hours, material, and direct-labor dollars are assigned.

In support of the Program B office, other program offices and functional elements, is a management system office staffed with approximately sixty people including planning, development and operations elements. The current IBM 370/145 central processing unit and peripheral support equipment are shown on the schematic on page 49 .[25] Typically, the management systems office is organized under the Division controller who reports to the Division president. Capabilities include ANSI Cobol for business systems programs and FORTRAN IV for scientific programming. RPG is not one of the capabilities offered since, according to Mr. L. B., the Division Manager of Management Systems, its desired use is low and therefore

[24] It should be noted by the reader that these internal detailed schedules were not made available to the author. It was here that the company drew the line which separates private, priviledged information from that which was considered releasable to the outside.

[25] Company B IBM 370/145 Computer System Schematic.


(6) 3420-5
3803-1
CONTROL
(4) TC60
TC 160
CONTROL
2501
35 25
35 05
370/145
3/4 MEG.
3215
1403-N1
1403-N1
2827-3
CONTROL
3704
360/30
64K
3780
3830-1
CONTROL
(4) 3330
2250

RJE/RALEIGH

not be cost effective. Reports generated for the program office to control both the research and development effort and the production effort of the subject Integrated Display Set change proposal include the following:

. Explosion Request (deliverable part numbers)

. Parts Number List

. Most Critical Parts Report

. Least Critical Parts Report

. Open Purchase Orders and Requisitions

. Part Number Inventory Allocation and Order Status

. Start List Work-In-Process System

. Direct Labor Distribution Report (weekly/monthly)

. Direct Material Report (weekly/monthly)

. DL/DM Variance Reports

. Direct Labor Efficiency Reports

. Project Budget Variance Report

Note: open purchase order and requisition: part number inventory allocation order status included as examples.[26]

Detailed variances determinations must be computed manually by program office personnel; usually the financial analysts. Variance analysis and reporting are done for both internal management (above program office level) and customer. Only basic schedule variance information is calculated manually and as far as the program office is concerned for the

[26] PUR 71502, PROG 72-900. Provided by Company B.

PURCHASE ORDER 'ER— —SECTION	VENDOR	PART NUMBER	REV	DESCRIPTION	REQN. NO.	PROJECT	DATE WS RECEIVED MO DA Y	DATE P.O. PLACED MO DA Y	REQN. QUANTITY BY. PROM. DT.	P. C. NEED DATE MO DA Y	QU OI
.2- -EG		158-130-0001	B	TRANSISTOR	36506	M253 50	10175		42	06016	
)6-0027906 -EG01	LAFAYETTE IND E	158-130-0001		TRANSISTOR	34091	M253 50	09105	09175	03016	05016	
.2- -EG		161-111-0001	U	MIC DEVICE	34092	M253 54	09105	CHECK	6	04016	
)6-762-002 -EG14	RAYTHEON CC	161-123-0004	C	MIC DEV.	92373	M253 00	09305	10105	12155	06186	
)6- -EG		161-184-0001		MIC DEVICE	92464	M253 00	10105		29	03126	
)6-0027916 -EG01	COMPONENTS PLUS	161-187-0001		MIC DEVICE	23947	M253 53	09105	09195	03016	05016	
.1-0027806 -MG01	W C CIRCUITS CO	3561-29182N		BOARD BOTTO	23952	M253 53	09105	09175	12305	06016	
11-0027808 -MG01	FLUID MECHANISM	3561-39322		GEAR	23964	M253 57	09105	09245	12305#	12015	
11-0027811 -MG01	DUO INSTRUMENT	3561-39331		KNOB	23965	M253 57	09105	09245	12305#	12015	
)6-0027654 -EG03	GEN INSTRUMENT	958-044-0001	A	TRANSISTOR	23977	M253 54	09125	10135	11155	06016	
12- -EG		958-049-0001	G	TRANSISTOR	34238	M253 50	09265	CHECK	50	08016	
)7- -EG		135-005-0001		SPARK GAP	92465	M254 00	10155		20	03126	
)7-0026627 -EG	01144A	107-030-0002		CONNECTOR A	21054	M255 53		06095	11155	12015	
10-0026628 -EG	10648	151-232-0002		TRANSFORMER	21066	M255 53		06105	12015	12015	
10-0024037RM-EG	10648	151-232-0002		TRANSFORMER	18981	M256 53		09185		11175	
10-0024037RN-EG	10646	151-232-0002		TRANSFORMER	18981	M256 53		09185		11175	
10-0026628 -EG	10648	151-232-0002		TRANSFORMER	21031	M256 53		06105	12015	02016	
45-0015998 -HS01	PENN OPTICAL CO	RAW GLASS		FOR COMBINE	83770	M258 50	08295	09165	12316#	09155	
05-0027288RM-MG01	THE NASSAU CORP	3562-60164		WASHER PIVA	88075	M258 00		10025		12015	
11-0027043 -MG01	JIG BORING SPEC	3562-64826-1	-	SUPPORT COM	88077	M258 00	07155	08195	11305#	11205	
11-0027043 -MG02	JIG BORING SPEC	3562-64826-2	-	SUPPORT COM	88077	M258 00	07155	08195	11305#	11205	
45-0015985 -ES01	PENN OPTICAL CO	3562-66610-01	8	SPHER COMBI	88072	M258 00	07155	07245	10315	11215	
45-0015965 -ES01									02066#	11215	
45-0015985 -ES01									12125#	11215	
45-0015985 -ES01									11145	11215	
45-0015965 -ES01									02206#	11215	
45-0015985 -ES01									03056#	11215	
45-0015985 -ES01									01236#	11215	
45-0015985 -ES01									12195#	11215	
45-0015985 -ES01									01096#	11215	
45-0015985 -ES01									11285#	11215	
40-0015945 -MS01	SHELLCAST FOUND	3562-66621-1X	-	RAW CASTING	88074	M258 00	07155	07175	09225	09255	
11-0027042 -MG01	JIG BORING SPEC	3562-66624	-	COMBINER MO	88073	M258 00	07155	08195	11305#	11205	
45-0015985 -ES02	PENN OPTICAL CO	3562-76610-01	8	SPHER COMBI	88072	M258 00	07155	07245	02066#	11215	
45-0015985 -ES02									01236#	11215	
45-0015985 -ES02									11285#	11215	
45-0015985 -ES02									12195#	11215	
45-0015985 -ES02									[illegible]	[illegible]	

```
        DORMANT INVENTORY          5              FIN STRS INV ALL PROJ         TOTALS    23          23
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      N 3561-2[illegible]-101  -7[illegible]-UP21    AMS 73-33-2                7[illegible]    -        1         1  P
      N 3561-2[illegible]-101  -7[illegible]-S[illegible]02    AMS 74-21-1                M220    -        1   3     3  P
      N 3561-2[illegible]-101  -7[illegible]-S[illegible]    AMS 74-31-2                M220    -        1   8     8  P
      N 3561-2[illegible]-101  -7[illegible]-S[illegible]    AMS 74-35-1                M220    -        1   8     8  P
      N 3561-2[illegible]-101  -7[illegible]-S[illegible]    AMS 74-49-1                M220    -        1  12    12  P
2J54 N 3561-2[illegible]-101  CVU ASSEMBLY      AMS 76-24-2  3561-51020-101  M251  999-999   1   1     1
        DORMANT INVENTORY                         FIN STRS INV ALL PROJ         TOTALS    33          33   *SHORT*
 PO-PR-NO#      PROJ  ID   ORD-QTY  PR QTY      VAD       NEED-DTE   STK-DATE  VENDOR NAME      BUYER
 NO 02773       M251  53      3                                      75-39-5
 NO 10516       M251  53      4                                      75-37-5
                  TOTAL       7
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
2J54 N 3561-2[illegible]      CURRENT SENSING  AMS 76-24-2  3561-51020-101  M251  999-999   1   1     1
        DORMANT INVENTORY                         FIN STRS INV ALL PROJ   11     TOTALS        1     1
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      N 3561-2[illegible]     -7[illegible]-S[illegible]74    AMS 74-29-1                M220    -        1  10    10  P
      N 3561-2[illegible]     -7[illegible]-S[illegible]74    AMS 74-29-2                M220    -        1   3     3  P
      N 3561-2[illegible]                       AMS 75-43-1                M253    -        1   8     8  P
2J54 N 3561-2[illegible]      PREREGULATOR BS  AMS 76-24-2  3561-51020-101  M251  999-999   1   1     1
        DORMANT INVENTORY        131              FIN STRS INV ALL PROJ         TOTALS    22          22   *SHORT*
 PO-PR-NO#      PROJ  ID   ORD-QTY  PR QTY      VAD       NEED-DTE   STK-DATE  VENDOR NAME      BUYER
 NO 10513       M251  53      4                                      75-37-5
                  TOTAL       4
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
2J54 N 3561-2[illegible]      [illegible]PER, IC2       DP  76-21-4  3561-2[illegible]    M253  999-999   1   8     8
        DORMANT INVENTORY                         FIN STRS INV ALL PROJ   25     TOTALS    8     8
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
2J54 N 3561-2[illegible]27    [illegible]PER, BOTTOM    DP  76-21-4  3561-2[illegible]    M253  999-999   1   8     8
        DORMANT INVENTORY                         FIN STRS INV ALL PROJ   25     TOTALS    8     8
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      N 3561-2[illegible]     -7[illegible]-S[illegible]      AMS 75-35-5                M220    -        1   9     9  P
        DORMANT INVENTORY        14               FIN STRS INV ALL PROJ         TOTALS     9           9   *SHORT*
 PO-PR-NO#      PROJ  ID   ORD-QTY  PR QTY      VAD       NEED-DTE   STK-DATE  VENDOR NAME      BUYER
 NO 02877       M220  53      9                                      75-41-5
                  TOTAL       9
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      N 3561-2[illegible]     -7723             AMS 73-20-3                M201    -        1   8     8  P
        DORMANT INVENTORY        75               FIN STRS INV ALL PROJ         TOTALS     8           8   *SHORT*
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      N 3561-2[illegible]     -7[illegible]-UP21      AMS 73-33-2                7[illegible]    -        1   3     3  P
      N 3561-2[illegible]     -7723             AMS 73-41-1                M202    -        1   9     9  P
      N 3561-2[illegible]     -7[illegible]-S[illegible]      AMS 74-29-1                M220    -        1   9     9  P
      N 3561-2[illegible]     -7[illegible]-S[illegible]      AMS 74-34-1                M220    -        1   8     8  P
      N 3561-2[illegible]     -7[illegible]-S[illegible]      AMS 74-39-4                M220    -        1   8     8  P
      N 3561-2[illegible]     -7[illegible]-S[illegible]      AMS 74-52-2                M220    -        1  13    13  P
        DORMANT INVENTORY                         FIN STRS INV ALL PROJ         TOTALS    50          50   *SHORT*
 PO-PR-NO#      PROJ  ID   ORD-QTY  PR QTY      VAD       NEED-DTE   STK-DATE  VENDOR NAME      BUYER
 NO 01975       M220  53      5                                      75-07-2
 NO 81032       M220  53      1                                      75-02-1
                  TOTAL       6
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      N 3561-2[illegible]     -7730             AMS 74-06-2                M201    -        1   7     7  P
        DORMANT INVENTORY        1                FIN STRS INV ALL PROJ         TOTALS     7           7   *SHORT*
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

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purpose of rescheduling Company B responsible delivery delays only.[27]

In order to determine program status, periodic visits by DCASO and DCAA personnel are conducted. Usually percent of program completion is determined by DCASO industrial engineers for the purpose of program progress payments. No similar external reports are generated. The preceding report examples are hardware oriented and provide little over-all visibility. The company's reluctance to divulging further information stemmed from fear of competitive disclosures and from the time involved to manually generate unique Program B data.

<u>SUMMARY</u>: As with Project A, Project B is managed by a program office rather than the company functional organization. Apparent use of ADPE exists as evidenced by the reports listed on page 50. However, this review was not allowed. On the other hand, Company B deviated from current literature concepts in areas of detailed work breakdown, (the Program Directive is cursory at best), detailed cost and

[27] The program office preferred not to release or discuss in detail the internal variance reports or labor efficiency reports since these reports and others served as the basis for future product pricing; a negotiable figure and one considered to be company private.

schedule variances and analyses, lack of any current sophisticated management techniques or systems in spite of an impressive MIS set-up and, as with Company A, only limited responsibilities for costs within the program office.

Visibility into the project suffers from the above noted deviations. External reporting was non-existant and internal reports closely guarded. Beginning with the issuance of the Program Directive, continuing with the basic schedule and finally by requiring personal visits by audit agencies to determine status, the depth of visibility into the project is shallow and in some cases non-existant. Forecasts of future expenditures appeared only in the Project Budget Variance Report which estimated funding requirements for only two months into the future.

The audit report for the period ending 31 Dec 1976 showed the project to be $70,000 over-run and ten weeks behind schedule. The program office as of 1 March 1976 had not completed its variance analysis.[28]

3 Note: current March 1 cost over-run equals $100,000 and fourteen week schedule slip.

CHAPTER V

COMPANY C

Corporation C is a diversified organization which markets products and services in such fields as insurance, entertainment, real estate, power plants and basic research and development. With sales in 1974 exceeding 600 million dollars,[29] the Corporation looks to Company C to carry its gas turbine line of general purpose and aviation engines.

The product line of interest in this paper is the gas turbine power plant candidate for Z Corporation's competitive effort versus X Corporation for a new battle tank system for the U. S. Army.

Company C is under contract for a target price of about 10 million dollars to develop and deliver to Z Corporation 15-20 pre-production turbines.

The company's sensitivity to the needs and desires of the customer prompted early in the contract development phase the establishment of a six to ten man dedicated program office. Staffed like Company A and Company B, Company C's program office has a program manager, a financial accountant, a contracts administrator, a scheduling co-ordinator and a variable number of system and functional engineers.

Both the master program schedule and the detailed lower tiered schedules are generated manually using the MOST scheduling techniques.[30]

29 Company C Annual Report, (1974), page 17.

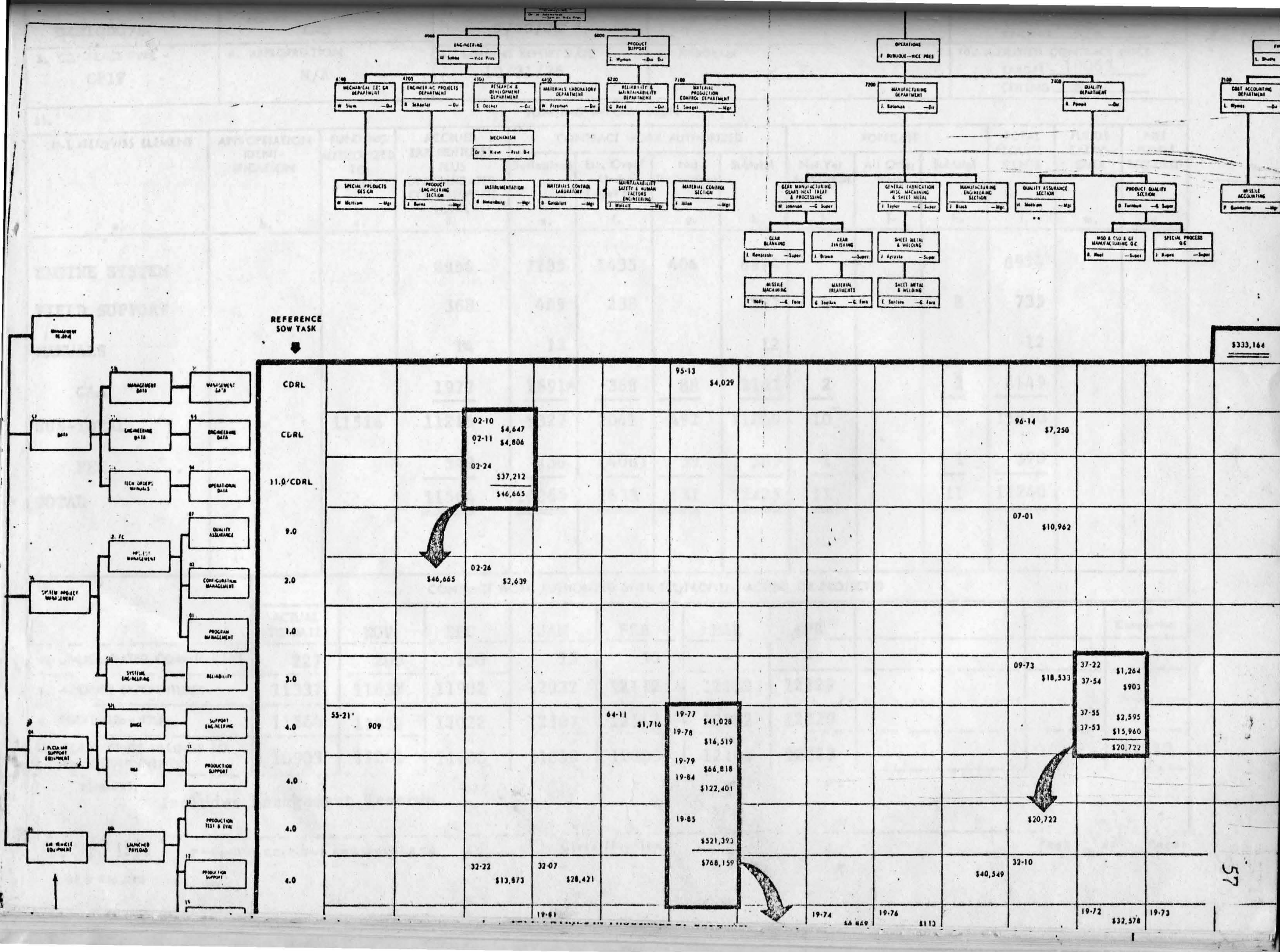
30 See Chapter III for a discussion and example of MOST scheduling chart.

A unique feature of this particular program in terms of management information is a requirement in the contract Statement of Work (SOW) that a formal Cost/Schedule Control Systems Criteria (C/SCSC) be implemented. As outlined in Chapter II, C/SCSC requires several features of management data as follows:

1. A contract WBS [31]
2. Assignment of specific work tasks to specific individuals [32]
3. Variances from planned cost and schedule for each work package reported each month [33]
4. Analyses required for all variances exceeding $5,000 [34]
5. Continuously up-dated "Estimated to Contract Completion" [35]

The above foot-noted examples (pages 57-62) of the Contract Funds Status Report and the Cost Performance Report contain required data obtained from Company C's Experimental Management Information System (EMIS) and other accounting systems. The company's Management Information System group

[31] Work Breakdown Structure organization matrix.
[32] ibid.
[33] Contract Funds Status Report, (October, 1975), Project C.
[34] Cost Performance Report, (October, 1975), Project C.
[35] ibid.


ENGINEERING
PRODUCT SUPPORT
OPERATIONS
MECHANICAL DESIGN DEPARTMENT
ENGINEERING PROJECTS DEPARTMENT
RESEARCH & DEVELOPMENT DEPARTMENT
MATERIALS LABORATORY DEPARTMENT
RELIABILITY & MAINTAINABILITY DEPARTMENT
MATERIAL PRODUCTION CONTROL DEPARTMENT
MANUFACTURING DEPARTMENT
QUALITY DEPARTMENT
COST ACCOUNTING DEPARTMENT
MECHANISM
SPECIAL PRODUCTS DESIGN
PRODUCT ENGINEERING SECTION
INSTRUMENTATION
MATERIALS CONTROL LABORATORY
MAINTAINABILITY SAFETY & HUMAN FACTORS ENGINEERING
MATERIAL CONTROL SECTION
GEAR MANUFACTURING GEARS HEAT TREAT & PROCESSING
GENERAL FABRICATION MISC. MACHINING & SHEET METAL
MANUFACTURING ENGINEERING SECTION
QUALITY ASSURANCE SECTION
PRODUCT QUALITY SECTION
MISSILE ACCOUNTING
GEAR BLANKING
GEAR FINISHING
SHEET METAL & WELDING
MISSILE MACHINING
MATERIAL TREATMENTS
SPECIAL PROCESS QC
REFERENCE SOW TASK
CDRL
CDRL
11.0/CDRL
9.0
2.0
1.0
3.0
4.0
4.0
4.0
4.0
$333,164
MANAGEMENT DATA
ENGINEERING DATA
TECH ORDERS MANUALS
OPERATIONAL DATA
DATA
QUALITY ASSURANCE
PROJECT MANAGEMENT
CONFIGURATION MANAGEMENT
SYSTEM PROJECT MANAGEMENT
PROGRAM MANAGEMENT
SYSTEMS ENGINEERING
RELIABILITY
SUPPORT ENGINEERING
PRODUCTION SUPPORT
PRODUCTION TEST & EVAL
AIR VEHICLE EQUIPMENT
LAUNCHED PAYLOAD
95-13 $4,029
02-10 $4,647
02-11 $4,806
02-24 $37,212
$46,665
96-14 $7,250
07-01 $10,962
02-26 $2,639
$46,665
09-73 $18,533
37-22 $1,264
37-54 $903
37-55 $2,595
37-53 $15,960
$20,722
$20,722
55-21 909
64-11 $1,716
19-77 $41,028
19-78 $16,519
19-79 $66,818
19-84 $122,401
19-85
$521,393
$768,159
32-22 $13,873
32-07 $28,421
32-10 $40,549
19-81
19-74
19-76 $113
19-72 $32,578
19-73
57

2. CONTRACT TYPE	4. APPROPRIATION	6. CURRENT REPORT DATE	8. PROGRAM	10. ADJUSTED CONTRACT PRICE
CPIF	N/A	10/31/75		TARGET 10063 CEILING N/A

11. FUNDING INFORMATION

LINE ITEM/WBS ELEMENT a.	APPROPRIATION IDENTIFICATION b.	FUNDING AUTHORIZED TO DATE c.	ACCRUED EXPENDITURES PLUS UNLIQUIDATED COMMITMENTS TOTAL d.	CONTRACT WORK AUTHORIZED: Definitized e.	CONTRACT WORK AUTHORIZED: Est. Over/Under Target Cost f.	CONTRACT WORK AUTHORIZED: Not Definitized g.	CONTRACT WORK AUTHORIZED: Subtotal h.	FORECAST: Not Yet Authorized i.	FORECAST: All Other Work j.	FORECAST: Subtotal k.	TOTAL REQUIREMENTS l.	FUNDS CARRY-OVER m.	NET FUNDS REQUIRED n.
ENGINE SYSTEM			8856	7135	1435	404	8974				8974		
FIELD SUPPORT			368	489	238		727	8		8	735		
MANUALS			14	12			12				12		
G&A			1977	1691*	368	88	2147	2		2	2149		
SUB-TOTAL		11516	11215	9327	2041	492	11860	10		10	11870		
FEE			349	738	(408)	39	369	1		1	370		
TOTAL			11564	10065	1633	531	12229	11		11	12240		

12. CONTRACT WORK AUTHORIZED (WITH FEE/PROFIT) - ACTUAL OR PROJECTED

	ACTUAL TO DATE	NOV	DEC	JAN	FEB	MAR	APR				At Completion
a. UNLIQUIDATED COMMITMENTS	227	200	150	75	30	-	-				
b. ACCRUED EXPENDITURES	11337	11637	11902	12032	12112	12182	12229				
c. TOTAL (12a + 12b)	11564	11837	12022	12107	12142	12182	12229				
13. FORECAST OF BILLINGS TO THE GOVERNMENT	10903	11261	11600	11850	12000	12100	12229				12229

REMARKS:
* Includes Management Reserve

CLASSIFICATION

COST PERFORMANCE REPORT — WORK BREAKDOWN STRUCTURE

CONTRACTOR: LOCATION: RDT&E ☐ PRODUCTION ☐ 17	CONTRACT TYPE / NO.: CPIF/DXN100078	PROGRAM NAME NUMBER	REPORT PERIOD: 10-1-75 thru 10-31-75	SIGNATURE, TITLE & DATE R. G. Mgr., Engineering Budgets & Pricing	FORM APPROVED OMB NUMBER 22R0280

QUANTITY	NEGOTIATED COST	EST COST AUTH. UNPRICED WORK	TGT PROFIT/FEE %	TGT PRICE	EST PRICE	SHARE RATIO	CONTRACT CEILING	EST CEILING
5	9,327,128	2,533,000	738,289	10,065,417	12,229,417	80/20	-	-

ITEM	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETION		
	BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		BUDGETED	LATEST REVISED ESTIMATE	VARIANCE
	Work Scheduled	Work Performed		Schedule	Cost	Work Scheduled	Work Performed		Schedule	Cost			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
WORK BREAKDOWN STRUCTURE													
A-1 Fwd Engine Module	14	22	17	8	5	403	390	367	(13)	23	409	744	(335)
A-2 Rear Engine Module	-	1	3	1	(2)	366	366	301	-	65	367	453	(86)
A-3 Reduct G/B & Piping	-	-	-	-	-	28	27	28	(1)	(1)	28	45	(17)
A-4 Access G/B & Piping	-	-	11	-	(11)	256	248	244	(8)	4	256	542	(286)
A-5 Engine Assembly	73	34	55	(39)	(21)	969	1,042	946	73	96	1,524	1,028	496
A-6 Engine Test & Eval.	48	48	85	-	(37)	619	550	590	(69)	(40)	653	671	(18)
A-7 Systems Eng'g./ Systems Eng'g. Mgt.	19	25	22	6	3	314	314	299	-	15	416	408	8
A-Total/Engine Subsystem	154	130	193	(24)	(63)	2,955	2,937	2,775	(18)	162	3,653	3,891	(238)
B-Vehicle Test Support	28	23	29	(5)	(6)	173	198	189	25	9	332	341	(9)
C-Oper. & Maint. Manual	-	-	-	-	-	2	2	3	-	(1)	2	3	(1)
SUB-TOTAL	182	153	222	(29)	(69)	3,130	3,137	2,967	7	170	3,987	4,235	(248)
GEN AND ADMIN	40	34	49	(6)	(15)	689	690	654	1	36	875	906	(31)
UNDISTRIBUTED BUDGET													
SUBTOTAL	222	187	271	(35)	(84)	3,819	3,827	3,621	8	206	4,862	5,141	(279)
MANAGEMENT RESERVE											170**		170
TOTAL	222	187	271	(35)	(84)	3,819	3,827	3,621	8	206	5,032 *	5,141	(109)

** $108K of total represents reserve for preliminary authorized estimate of S/N's 26-27-31-32 updates.

RECONCILIATION TO CONTRACT BUDGET BASELINE

VARIANCE ADJUSTMENT													
TOTAL CONTRACT VARIANCE													

(ALL ENTRIES IN THOUSANDS OF DOLLARS)

LOCATION:

ROT&E ☒ PRODUCTION ☐

CONTRACT TYPE / NO.: CPIF/DXM100078

PROGRAM NAME/NUMBER:

REPORT PERIOD: 10-1-75 thru 10-31-75

OMB NUMBER 22R0280

ORGANIZATIONAL OR FUNCTIONAL CATEGORY	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETION		
	BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		BUDGETED	LATEST REVISED ESTIMATE	VARIANCE
	Work Scheduled	Work Performed		Schedule	Cost	Work Scheduled	Work Performed		Schedule	Cost			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
ENGINEERING	110	124	171	14	(47)	1,499	1,442	1,505	(57)	(63)	1,850	1,902	(52)
MANUFACTURING	60	23	40	(37)	(17)	1,370	1,438	1,243	68	195	1,853	2,064	(211)
OTHER	1	1	2	-	(1)	20	20	24	-	(4)	27	36	(9)
TOOLING	-	-	-	-	-	58	55	25	(3)	30	58	27	31
QUALITY	11	5	9	(6)	(4)	183	182	170	(1)	12	199	206	(7)
SUB-TOTAL	182	153	222	(29)	(69)	3,130	3,137	2,967	7	170	3,987	4,235	(248)
GEN AND ADMIN	40	34	49	(6)	(15)	689	690	654	1	36	875	906	(31)
UNDISTRIBUTED BUDGET													
TOTAL	222	187	271	(35)	(84)	3,819	3,827	3,621	8	206	4,862	5,141	(279)

(Note: This total must agree with Subtotal on Format 1)

(ALL ENTRIES IN THOUSANDS OF DOLLARS)

Format 2

CONTRACTOR LOCATION	Street COST PERFORMANCE REPORT - PROBLEM ANALYSIS			Form Approved Budget Bureau No. 22R0280
RDT&E ☒ PRODUCTION ☐	CONTRACT NO: DXM 100078	PROGRAM NAME NUMBER:	REPORT PERIOD: 10/1/75 - 10/31/75	

Section 3. Narrative Description

AGT 1500 Engine Package	Current Month	Cumulative to Date
Schedule	$29K Unfavorable	$ 7K Favorable
Engine Subsystem	$24K Unfavorable	$18K Unfavorable

- o Forward Engine — $14K Favorable

The monthly variance is the result of receiving hardware for DF-2 rig and engine tests later than anticipated.

- o Engine Assembly — $22K Unfavorable

The unfavorable monthly variance was caused by not earning BCWP during this period because the task supervisor was on leave. The necessary adjustments will be made in the November report.

- o Engine Test & Evaluation — $57 Unfavorable

The cumulative variance is caused by not completing the DF-2 test program in October as planned. The assembly of the engine for the 25 hours of engine testing was completed during the reporting period. Final preparation of the engine for test is underway with testing scheduled to begin in early November. Associated rig test work packages will remain open in the event that complementary testing is required.

Also contributing to the variance is the inspection of the 400 hour NATO test engine which will continue into November.

CONTRACTOR LOCATION	COST PERFORMANCE REPORT - PROBLEM ANALYSIS			Form Approved Budget Bureau No. 22R0280
St.				
RDT&E ☒ PRODUCTION ☐	CONTRACT NO: DXM 100078	PROGRAM NAME NUMBER:	REPORT PERIOD: 10/1/75 - 10/31/75	

	Current Month	Cumulative to Date	At Completion
Cost	$69K Unfavorable	$170K Favorable	$248 Unfavorable
Engine Subsystem	$63K Unfavorable	$162K Favorable	$238 Unfavorable

o Rear Engine — $ 45K Favorable (Cumulative to Date)

The cumulative variance is attributed to BCWP being recognized for positive Recuperator variances as reported in the April 1975 report.

o Engine Assembly — $152 Favorable (Cumulative to Date)

The cumulative variance is caused by BCWP being recognized for additional hardware requirements as discussed in the July 1975 report.

o Engine Test and Evaluation — $19K Unfavorable (Current Month)

The monthly variance is the result of not earning BCWP when anticipated for the DF-2 test program and the post 400 hour test inspection as discussed above.

Functional - the functional cost variance for engineering has been discussed above.

is responsible for software generation, file maintenance and computer operations for all systems including EMIS. Organized under the Vice-President of Administration, the *Management Information Systems group, some sixty people in* number, is fully responsive to the needs of research and development programs. Current hardware layout is depicted in the diagram on page 64.[36] EMIS is a computerized system for control and status of design and development projects under the Vice-President of Engineering.

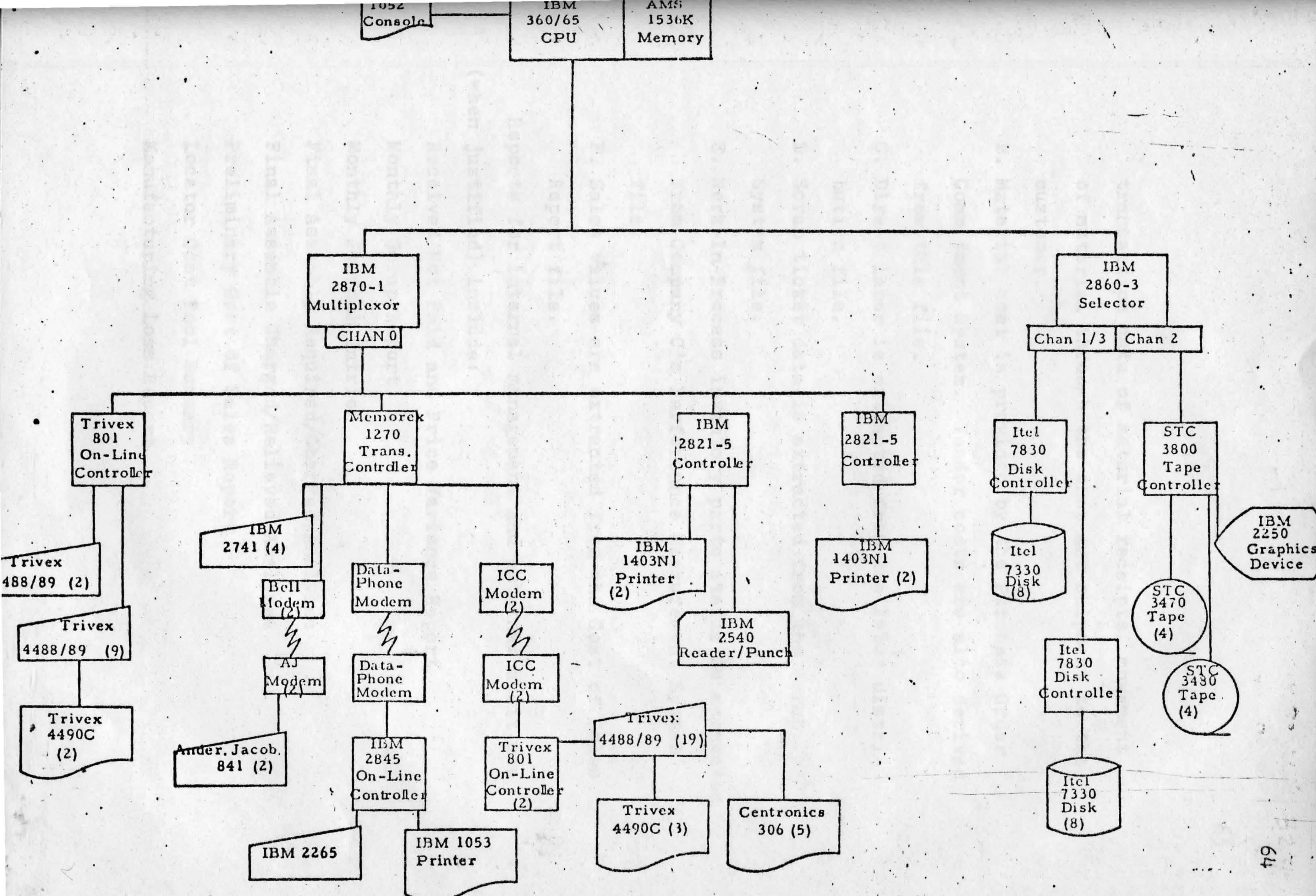
The EMIS Work-In-Process System produces three main outputs: W-I-P Status, Daily Schedule, and 8-Week Schedule and Shop Load.

The Wrok-In-Process Report is printed daily and reflects the current Work-In-Process status. This current status is determined by combining the previous status with all the transactions made during the preceding work day. The report yields information in the whereabouts of paricular parts, the quantity at particular operations, the employee performing the last reported labor, the predicted completion date for the job, and many other items of interest to Experimental Manufacturing and Control Supervision.

Data sources, in addition to the WIP control system for use in the various program control and status reporting systems include:

A. The Automated Inventory System provides the

[36] Computer schematic, Company C; provided by MIS director, Mr.R.



1052 Console
IBM 360/65 CPU
AMS 1536K Memory
IBM 2870-1 Multiplexor
CHAN 0
IBM 2860-3 Selector
Chan 1/3
Chan 2
Trivex 801 On-Line Controller
Memorex 1270 Trans. Controller
IBM 2821-5 Controller
IBM 2821-5 Controller
Itel 7830 Disk Controller
STC 3800 Tape Controller
IBM 2250 Graphics Device
Trivex 4488/89 (2)
IBM 2741 (4)
Bell Modem (2)
Data-Phone Modem
ICC Modem (2)
IBM 1403N1 Printer (2)
IBM 1403N1 Printer (2)
Itel 7330 Disk (8)
STC 3470 Tape (4)
Trivex 4488/89 (9)
AJ Modem (2)
Data-Phone Modem
ICC Modem (2)
IBM 2540 Reader/Punch
Itel 7830 Disk Controller
STC 3480 Tape (4)
Trivex 4490C (2)
Ander. Jacob. 841 (2)
IBM 2845 On-Line Controller
Trivex 801 On-Line Controller (2)
Trivex 4488/89 (19)
Itel 7330 Disk (8)
IBM 2265
IBM 1053 Printer
Trivex 4490C (3)
Centronics 306 (5)

transaction data of material receipts, movement of material through the shop and shipment to the customer.

B. Material cost is provided by the Purchase Order Commitment System. Vendor costs are also derived from this file.

C. Direct labor is extracted from the labor distribution file.

D. Scrap ticket data is extracted from the Scrap System file.

E. Work-In-Process inventory parts status is extracted from Company C's Performance Measurement System file.

F. Sales values are extracted from the Cost of Sales Report file.

Reports for internal management and external audit use (when justified) include:

Received Not Paid and Price Variance Report

Monthly Scrap Report

Monthly Journal Entries

Final Assembly Required/Charged Analyses

Final Assemble Charged/Relieved Analyses

Preliminary Cost of Sales Report

Locator Cost Pool Summary

Manufacturing Loss Report

Error Identification Reports

System Exception Reports

Equivalent Unit Report

Control Data File Printouts [37]

The important points gained from the examination of Company C's Project (C) are that several advanced systems, and many of the above reports, are used to provide data for the Contract Funds Status Report (page 58) and the Cost Performance Report (page 59) and the subsequent narrative cost and schedule variance analyses reports.

<u>SUMMARY</u>: Company C's conformity to current literature concepts of R and D management systems is closer than either Company A or Company B: a complete program office with full responsibility for all cost, schedule and performance parameters; sophisticated systems which generate timely cost and schedule data, variances and analyses; monthly estimates to completion; subsequent fiscal year funding requirements; current ADPE and a complete MIS group; and the use of advanced control techniques such as MOST, EMIS, and C/SCSC.

Internal and external visibility gained from the extensive use of sophisticated systems varies from general summaries for top management to the cost/schedule status of the lowest element in the Work Breakdown Schedule. It could

[37] <u>Monthly Cost Accounting System</u>, Chapter I, page 6.

easily be argued that more visibility into Project C is available than can possibly be used. It is known from experience that only the exceptions from both the EMIS WIP status report and the EMIS Daily Schedule Report are addressed; the remaining information is never used. A clear picture of the program's status is given in the Contract Funds Status Report, the Cost Performance Report and attached cost and schedule variance reports.

CHAPTER VI

ANALYSIS AND CONCLUSIONS

This chapter determines the relative achievement of the original objectives:

. adherence to literature concepts

. depth of visibility

. effectiveness of each system

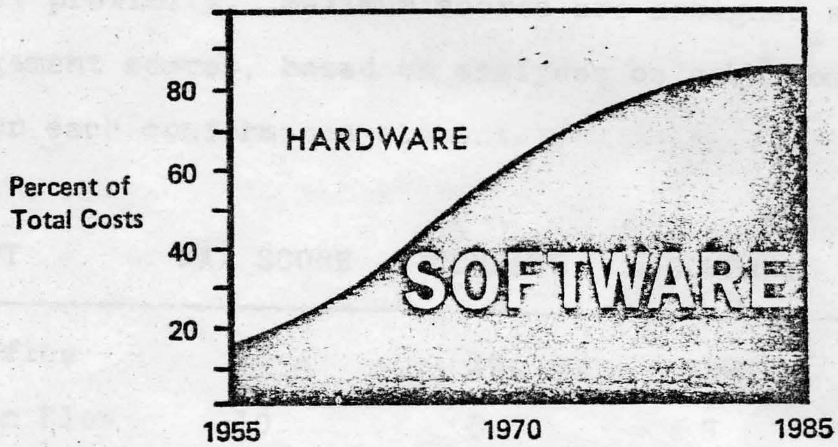
. correlation of modern concepts and depth of visibility to the effectiveness of the particular system.

The chapter also analyzes deviations and presents conclusions.

With regard to the literature search and the modern concepts of R and D information systems so determined, a paradox exists: a text or an article for the Harvard Business Review can be written expounding the virtues of this system or that by functional experts who, in the real world of business and profits, may not be able to put those concepts into practice. During the literature search phase it was noted that information systems should be uniquely tailored to the R and D project at hand; yet only Company C had any degree of such tailoring to its project. Perhaps the diagrams on the following page illustrate the problems industry faces when attempting to create systems specifically for any particular project.[38] Figure 1 illustrates the continuing growth of software costs versus the relative

[38] Defense Management Journal, (October, 1975), page 24.

decreasing cost of hardware. As Figure 2 shows, changes made to existing software induce new "bugs" which take time to shake out. New software is even more prone to the phenomenon.



Hardware/Software Trends

Figure 1

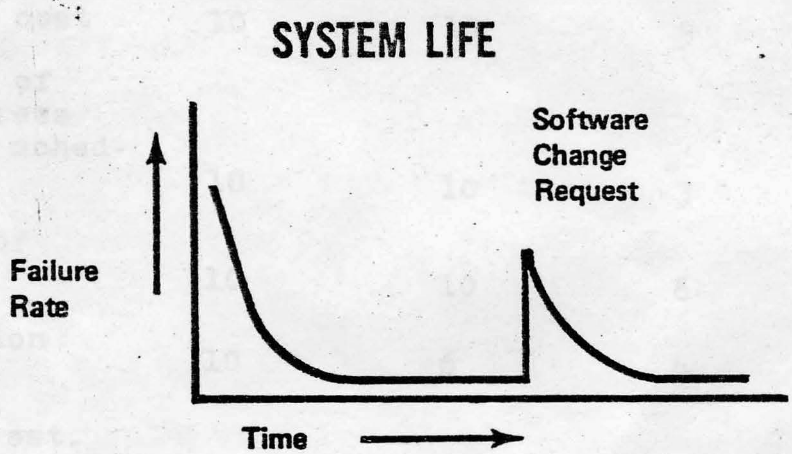


Figure 2

Even so, the literature search did highlight many modern, successfully tried techniques which are found in one degree or another within each company and which, on first analysis, are possible indicators of good management practices. The following matrix scores each company's conformance to the literature concepts with the highest score in each box indicating the closest proximity. Maximum scores are assigned arbitrarily; value judgement scores, based on analyses os each company, are awarded for each conformance element.

ELEMENT	MAX SCORE	COMPANY A	COMPANY B	COMPANY C
Program Office	10	10	10	10
Information Flow	10	8	8	10
Work Breakdown	10	9	5	10
Measurement of actual progress vs. planned cost	10	10	3	10
Measurement of actual progress vs. planned schedule	10	10	3	10
Timeliness of Reports	10	10	6	8
Sophistication of systems	10	6	4	8
Prediction, est. @ completion	10	10	0	10
Advanced APDS	10	10	10	10
Value judgement of MIS group contribution	10	9	8	8
	100	92	57	94

The depth of visibility provided by each company's system varies from company to company. It is assumed that the visibility needed is determined by the unique requirements of the particular contract project, the experience of the various program offices, the technical complexity of the project, and the age of the project. Proper visibility into any project is gaged by the rapidity with which management detects deviations from plan and the ease and rapidity with which corrective action is taken. The matrix on the following page scores each company on selected parameters of insight into each project. As with the conformance factors, value scores are awarded to each company based on the analysis of each depth of visibility element in order to rank each company on its ability to provide in-depth visibility into the progress of each R and D project.

The effectiveness of the information systems as applied to each project is determined by both objective and subjective techniques. The attempt here is to speak only in objective terms. Thus, even data which are considered necessary are sometimes excluded on the grounds that they are too subjective for value scores. The effectiveness matrix on page   scores each company with the higher the score the more effective the information system is believed to be. The matrix is divided into Part A (information system output elements) and Part B (Program A, B, and C status as of 31

ELEMENT	MAX SCORE	COMPANY A	COMPANY B	COMPANY C
Timeliness (daily, weekly, monthly)	10	10	7	8
Number of reports (ADP)	38	36	20	37
Number of reports (manual)	2	2	1	2
Work Breakdown	10	10	5	9
Project Schedule detail	10	9	5	9
Cost variance external	5	5	2	5
Schedule variance external	5	5	2	5
Variance analysis	10	5	5	10
Sophisticated techniques	10	7	5	10
Redundant/ excessive reports	-10	-2	0	-8
TOTALS:	100	87	52	87

	ELEMENT	MAX SCORE	COMPANY A	COMPANY B	COMPANY C
	Cost, schedule and performance data (internal)	5	5	5	5
	Cost, schedule and performance data (external)	5	5	3	5
ART A	Cost, schedule variance (ext)	5	5	3	5
	Detailed variance analysis	5	3	3	5
	Estimates to completion	5	5	0	5
	Follow-on fiscal year funding requirements	5	5	0	5
	Program status	70	70	70	70
	Cost over-run	-10	NA	-10	-10
	Schedule over-run	-10	NA	-10	-10
ART B	Cost under-run	-2	-2	NA	NA
	Schedule under-run	-2	-2	NA	NA
	Percent Variance (see calculation Page 75)				
	Over-run / Under-run	-10 / -2	-3	-16	-9
	Variances causes unknown	-10	-5	-10	0
	TOTAL Part A & Part B	100	86	38	71

December, 1975). For Part B, each program was awarded a maximum 70 points, then penalized depending on the severity of the elements shown.

It is acknowledged that Part B (current 31 December, 1975 status) reflects data which is in addition to that provided by the company information system, Difficult decisions must be made by management which may be contrary to placing the program on target cost and schedule in any particular month. Quite obviously, the information system should not be penalized if it provides data which identifies problem areas to management, who for a multitude of reasons, chooses to ignore the warnings. The MIS data, however, may have a reputation for being non-reflective of real time status, prone to errors, improperly emphasizing areas of program office interest or other intangible shortcomings.

It is therefore believed that Part A (information system deficiencies in conformity, effectiveness, and depth of visibility) and Part B (management personnel interaction) contribute concomitantly to the degree shown to warrent penalties as indicated by the sum of Parts A & B.

Percent Variance (PV) calculations yield a number for each company which considers the following elements:

a. <u>Over-run</u> or <u>under-run</u>: if the program is in an over-run condition (Company B & C) minus 10 points are assigned. If the program is in an under-run condition (Company A), then minus 2 points are assigned.

b. <u>Combined dollar value</u> of cost variance and effect of schedule variance. This fraction uses actual dollar variances as shown in the Cost Performance Report for Company C (Chapter V), (119), the Cost/Schedule Status Report for Company A (Chapter III), (189), and information gained from Company B during a plant visit in February, 1976, (100).

c. <u>Time fraction since start of program</u>: This fraction (time since start/total time) includes the number of months since program start devided by the total number of months scheduled in the contract. This number showed the rate at which each company deviated as of 31 December 1975.

The formula and separate calculations are shown below:

$$PV = \text{over-run or under-run score} \times \frac{\text{cost var + dollar effect of sched. var.}}{\text{total value}} \times \frac{\text{time since start}}{\text{total time}} \times (100$$

COMPANY A: $(-2)\ \frac{(189)}{3292}\ \frac{(7)}{24}\ (100) = -3.3$ or -3

COMPANY B: $(-10)\ \frac{(100)}{2100}\ \frac{(4)}{12}\ (100) = 15.8$ or -16

COMPANY C: $(-10)\ \frac{(119)}{9327}\ \frac{(34)}{48}\ (100) = -9.03$ or -9

The relationship of modern concepts in information systems as suggested by the literature and depth of visibility to information effectiveness is as logic might indicate, quite good. That is if a project is using advinced modern R and D information system techniques with a great deal of schedule and cost visibility, there is a high probability that management is obtaining usable data and that the program is on or near to target. This correlation can be seen from data in the following matrix:

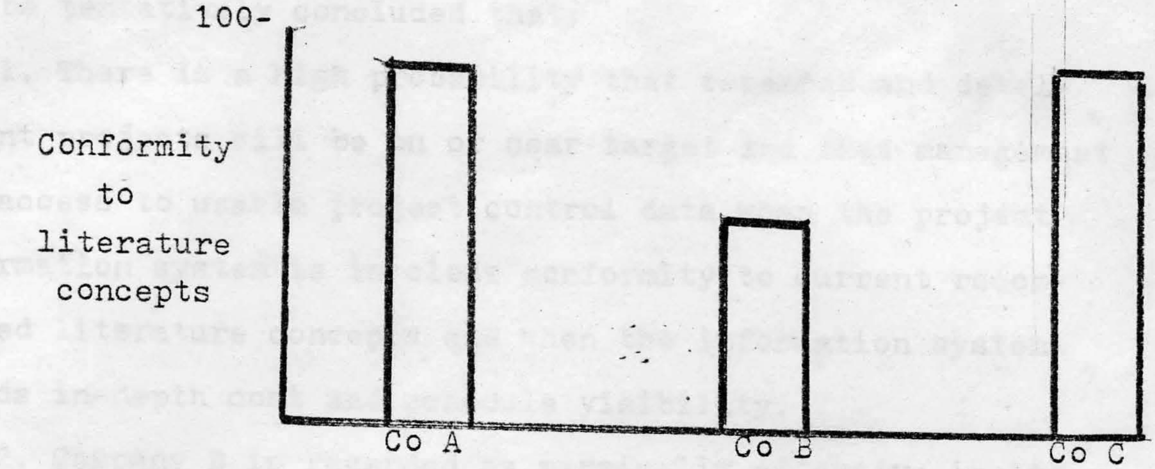
	MAX SCORE	COMPANY A	COMPANY B	COMPANY C
I. Techniques from literature search	100	92	57	94
II. Depth of visibility	100	87	52	87
III. Information system effectiveness	100	86	38	71

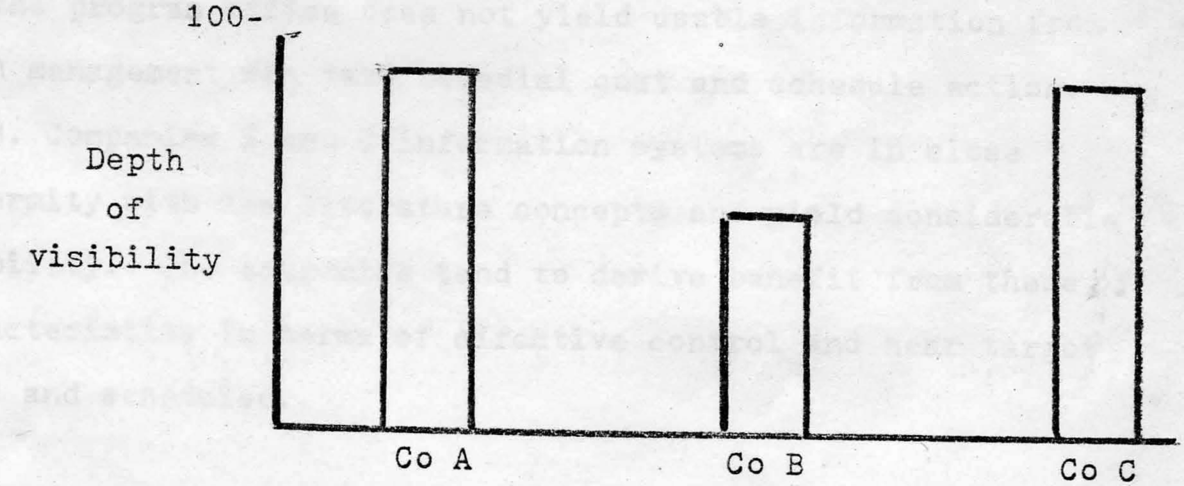
Relative factor:

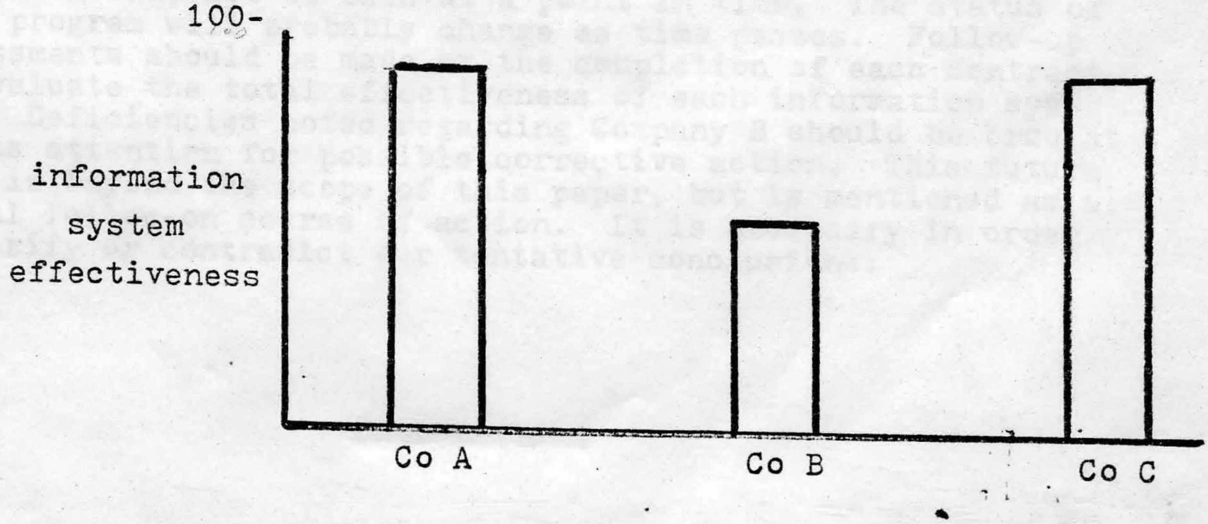
$$\frac{\text{Company literature conformance and company depth of visibility}}{\text{Maximum literature conformance and maximum depth of visibility}}$$

	COMPANY A	COMPANY B	COMPANY C
	89.5	54.5	90.5

The charts below graphically display the results of the above matrices in relative form:







CONCLUSIONS:

Based upon the limited data and assessment to date, [39] it can be tentatively concluded that:

1. There is a high probability that research and development projects will be on or near target and that management has access to usable project control data when the project information system is in close conformity to current recommended literature concepts and when the information system yields in-depth cost and schedule visibility.

2. Company B is regarded as marginally effective in its use of information systems on Project B. The data generated for the program office does not yield usable information from which management can take remedial cost and schedule action.

3. Companies A and C information systems are in close conformity with the literature concepts and yield considerable visibility. The companies tend to derive benefit from these characteristics in terms of effective control and near target costs and schedules.

[39] This thesis was necessarily prepared midstream in the programs - a snapshot of each at a point in time. The status of each program will probably change as time passes. Follow-up assessments should be made at the completion of each contract to evaluate the total effectiveness of each information system. Deficiencies noted regarding Company B should be brought to its attention for possible corrective action. This future work is beyond the scope of this paper, but is mentioned as a normal follow-on course of action. It is necessary in order to verify or contradict our tentative conclusions.

BIBLIOGRAPHY

Block, E. B. : "Accomplishment/Cost: Better Project Control", Harvard Business Review, May-June 1971.

Cleland, D. J., King, W. R.: Systems Analysis and Project Management, McGraw-Hill Book Co., New York, 1968.

Cohen, B. J.: Cost Effective Information Systems, AMA Inc., New York, New York, 1971.

Department of the Air Force, AFSCP 173-3 Cost/Schedule Control Systems Criteria (Implementation Guide), July 1969.

Forkner, I., McLoed, R. Jr.: Computerized Business Systems, John Wiley and Sons, New York, New York, 1973

Foster, J. S.: Defense Management Journal Government Printing Office, Alexandria, Virginia, 1973.

Goldschmidt, Y.: Information for Management Decisions, Cornell University Press, Ithica, New York, 1970.

McCarthy, Rita: Defense Management Journal, Government Printing Office, Alexandria, Virginia, 1975.

Milliken, J. G,; Morrison,: Management Methods from Aerospace, Harvard Business Review, March-April, 1973.

Murdick, R. G., Ross J. E.: Information Systems for Modern Management, Prentice Hall Inc., Englewood, N.J., 1971.

Offenhartz, Edward: Defense Management Journal, Government Printing Office, Alexandria, Virginia, 1974.

OTHER

Company A: Annual Report, 1975
(Norwalk, Ct., 1975)

Company B: Annual Report, 1974
(East Hartford, Ct., 1975)

Company C: Annual Report,1974
(Stamford, Ct., 1975)

Cost Proposal Report, No. 12470, Comapny A.

Program Directive, Project B, October, 1975. Company B.

Various handout material from Companies A,B,&C.

Interviews with Messrs. L.G., F.B., J.B. from companies A,B, and C respectively.